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RESEARCH ARTICLE

Open digital infrastructures for bridging professional cultures: the case of extreme citizen science between journalism and research

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Abstract

In this paper, we suggest framing citizen science projects as interprofessional collaborations. We first focus on one case study — the PLACES project — implementing three "extreme citizen science" collaborations between social scientists and journalists. We then show that in order to enable successful collaborations, participants need to be supported in aligning their professional practices, goals, and ways of framing the research problem. In the second part, with insights from another project (COESO), we show how dedicated infrastructures, understood as social and technical ecosystems, can support the creation of communities of practice, thus bridging the gap between the professional cultures of the people involved in citizen science endeavours. Another key condition for the success of extreme citizen science projects relies on the projects' governance, which can be influenced by the infrastructures' design.

Keywords

citizen science, interprofessional relation, community of practice, infrastructure, academic blogging, platform design



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Plain language summary

How can practitioners from different professional fields work together? Here, we present the case of collaborations between journalists and researchers in social sciences. These collaborations are called "extreme citizen science". We also present how these collaborations can be supported by specific "digital infrastructures", that is to say tools or platforms - but also the people managing them - that provided the needed help for practitioners to succeed their collaborations.

We first present the PLACES project, and its results. PLACES is a project carried out between 2018 and 2020 in France, enabling the implementation, observation, and analysis of three projects where journalists and social scientists run together a joint research project. Then, the analysis also takes into account the ongoing experimentations of the European project COESO, launched in 2021 and follows suit PLACES.

We present first the strengths and obstacles of the researcher-journalist collaborations we observed; then we highlight the importance of supporting the participants of a collaborative project in learning how to work together. We also underline how "digital infrastructures" such as platforms, can help building "community of practice": groups of people sharing a common concern, a set of problems, or a passion about a topic, and interacting on an ongoing basis to solve these common problems or deepen a shared knowledge.

In the second part, we discuss the role of digital platforms, stressing their value in supporting these collaborations, not only for letting participants create common results, but also to help them understand the challenges they face in sharing knowledge among their respective professional fields. We finally discuss the importance of the organisation of the work within these collaborations - who takes the decisions, how the work is shared (this is the "governance" of the project) - and the role that platforms can play in shaping the projects' governance.

Introduction

The long history of the relationships between research and society (Pestre, 2006) - particularly within the social science and the humanities (Albert *et al.*, 2021), and the increasing interest for renovated collaborations between the two (Mahr *et al.*, 2018), invite us to keep an eye on the diversity of approaches that bridge these supposedly separated worlds. To comprehend these relationships, it is important to pay attention to the articulation of "epistemic cultures" - in other words to the different ways to know and build knowledge - and to the ways these fashions to know are embodied in the social world (Knorr-Cetina, 1999). More especially, the relationships between research and society also depend on "professional cultures" (Bloor & Dawson, 1994) - that is to say the organisation of day-to-day practices within each branch of work activity - where each professional culture is a context in which the research-society relations are posed differently.

In this paper, we build on the hypothesis that infrastructures play a key role in bridging professional cultures, and in enabling and supporting the comprehension and collaboration between epistemic cultures. Infrastructures provide their framework, norms and procedures, and they are therefore suited to guide practices and to make these practices work together among different professional worlds. To understand this role of infrastructures, it is necessary to understand "infrastructure" as made up of both technical and social components, as bringing together technical devices and humans (Bowker *et al.*, 2010). Our focus will be on some platforms and services favouring collaborations, to highlight how they can shape citizen science practices involving the social sciences and humanities disciplines.

Considering citizen science as a specific case of interprofessional relationship including practitioners from academia, we draw from present the PLACES project, a case study that has been carried out in France and implemented three examples of collaborations between researchers and journalists. The latter investigated the same fieldwork in pairs, had the task of achieving what can be called "extreme citizen science" (Haklay, 2013): a collaborative, completely integrated activity, where the partners are equally involved in choosing the scientific problems to work on, and in defining the methods and means of data collection. These collaborations have been implemented and studied over a period of 18 months, from 2018 until 2020. Then, we will broaden our frame by taking into account the ongoing experimentations in the framework of the European project COESO that was launched in 2021 and follows suit PLACES. Both projects' main objective is to build a digital platform supporting and enhancing citizen science projects involving the social sciences and the humanities, with a particular attention to small scale - no more than ten people - and high intensity, "extreme", collaborative research projects.

Observing the projects' implementation, we found out that in collaborative projects the participants face specific challenges, and they express needs to address them. By searching how to address these needs, one efficient solution emerged, that of an external sociotechnical device, that we called a "third party" actor. We also observed that interprofessional collaborations and the role of the third party actor raise questions about governance, both of the citizen science projects and of the infrastructure, which can be addressed by working on the infrastructures' design.

The outline of this paper will follow this very path: in the first part, we will present the PLACES project's experimental apparatus, as well as its main results, intertwined together with the COESO project; we will then introduce the Hypotheses.org blogging platform and its particular uses as a collaborative device within the two projects. In a second part, we will give account of some of the trials encountered by the project's participants and the needs they raise, in order to explain the role of a third party actor. Finally, we will conclude by raising some of the challenges that citizen science projects generate in terms of governance, and how the design of an infrastructure can be used to address them.

Case studies of extreme citizen science between journalists and researchers

We will start by returning back over the experimental framework of the PLACES project and its main results, in order to

thoroughly present the research that supports our argument on digital and open infrastructures. This will lead us to underline the three main lessons of this experimentation, concerning the assumption of responsibility for the work of "articulation" (Strauss, 1985), the support of mutual learning and the constitution of communities of practice. The Strauss concept of "articulation" will be particularly mobilised in this paper: it refers to the specific professional activities that make up the unity of a complex project beyond the various organisational units and subunits, by meshing the numerous tasks, the efforts of various workers and the actors (Strauss, 1985, p. 8).

PLACES, funded by the French Ministry of Culture, was conceived by Pierre Mounier and one of the co-authors of this paper, Alessia Smaniotto, as an experimental project to solve the following research innovation question: how is it possible, through a new digital service platform, to facilitate and foster the connection between social science and humanities (SSH) researchers and journalists, in order to fill the "communication gap" between performed SSH research and its uptake by society?

We chose to focus on journalism because of the already old history of interactions between journalists and social scientists characterised by the ambivalence of the relations between the professionals of these two professional worlds (Campbell, 2006). They share aims and working methods, which are close in their concern to produce knowledge (Lindner, 1996), but which are also the object of very distant representations in terms of their implementation. From this point of view, these two professions promise collaborations that are at the same time fertile in conjunction as in tensions, and therefore fecund in opportunities for observation and analysis.

PLACES' question rapidly evolved towards a larger perspective, thus finding its place, while being implemented, into the larger landscape of the European "science with and for society" work program: the PLACES coordinators were indeed also preparing a response to a European project call focused on citizen science, in order to build the "research for society service" of the European research infrastructure OPERAS. The initial research innovation question thus broadenedwithin this larger perspective: how to facilitate and foster the connection between researchers in the fields of social sciences and humanities and the society at large, through a "research for society" service, focused on extreme citizen science?

The COESO ("Collaborative Engagement on Societal Issue") project, funded by the European Commission and launched in January 2021, has been developing since 2018 - intertwining with PLACES implementation - to reach this aim. Like PLACES, COESO is an experimental project including several research "pilots", or use-cases of collaborative research, now including not only journalists-researcher collaboration, but also collaborations between academic researchers and artists, activists, and non-academic research performing organisations. Within COESO, the observation and comprehension of these diverse types of collaborative citizen science projects, nourish the development of this new platform called "Virtual Ecosystem for Research Activation" (VERA), that will complement the Hypotheses.org blogging platform and become part of the "Research for society" service of the OPERAS research infrastructure. The design of VERA benefits from research on and comprehension of the pilots, and the involvement of their participants in the platform co-design process.

If we are summarising here these specific details, it is to underline that the whole experiment has been conceived within the social sciences and humanities (SSH) research infrastructures environment, mission-oriented toward fostering open science practices and aiming at enhancing the SSH research uptake and recognition within society at large. Indeed, the research questions were raised within the framework of the growing European research infrastructure OPERAS - committed to the development of open scholarly communication in the social sciences and humanities, whose coordination is ensured by the French research infrastructure OpenEdition, in collaboration with another national infrastructure, Huma-Num. As stated below, the experiment also builds on an existing platform and service, Hypotheses.org, conceived and managed by OpenEdition, dedicated to academic blogging for the social sciences and the humanities.

The PLACES project

The general ambition of the PLACES project was to prototype a digital platform able to support collaborations between journalists and researchers in social sciences and humanities, in order to help them to address societal issues jointly (in the PLACES pilots' cases, the societal issues were: the municipal election campaign, voluntary amenorrhoea and early-onset Alzheimer's disease). As the funding framework for PLACES was specifically oriented towards innovation in the press sector, an additional objective was to ponder over the evolution of the profession of journalist in two ways: by evaluating the benefit of working in closer collaboration with researchers in the social sciences and the humanities field, and by enhancing the inquiries methodologies to tackle societal issues thanks to an increased awareness about the conditions of production of scientific knowledge in these fields.

This approach led to the formulation of the two main hypotheses. First, it was to be considered that the excessive compartmentalisation of professional practices between these two professional worlds is likely to be an obstacle when journalists attempt to analyse with finesse and complexity the social issues they are interested in. By extension, it may also be an obstacle for their readers, listeners, or viewers to accurately understand the issues at stake in these subjects. The second hypothesis assumed that a citizen science approach could also constitute a reliable channel for the circulation of scientific knowledge outside the academic world, through mutual learning processes between individuals from different professional backgrounds. This last point led us to open up our reflections on the need to transform professional practices, to consider also the need for researchers to question their conception and ways of producing knowledge.

Three pilot projects received funding and are characterised by being brought together by a journalist - hired by one of the media partners of the project (Cafébabel, 20 Minutes and Binge Audio) — and a researcher - hired by the EHESS — working in pairs. Each pair was offered to collaborate in an investigation on a topic of their choice, with the aim of contributing to it in equal measure in all the research phases. The only constraint imposed was to produce at least one data set together. They were invited to publish the analysis of this data if only in the case that their collaboration developed to that extent.

The first pair, Safouane Abdessalem and Daniela Trucco, looked at the place of migration and border issues during the 2020 French municipal campaign. They published three press articles with CafeBabel. A second pair, made up of Aude Lorriaux and Julie Ancian, studied the social uses of contraception techniques by inquiring on voluntary amenorrhoea. They published five press articles, including the front page on 5 June 2020, and a podcast on the 20 Minutes news outlet website, as well as a post on the PLACES project research blog. The third pair, Alexandra Caria and Agathe Charnet, focused on the issue of young Alzheimer's patients. They produced a podcast series in four 15-minute episodes for Binge Audio.

A fourth study was carried out in parallel, whose primary objective was to observe these three pilot projects in order to observe the collaborations taking place on a day-to-day basis, to define the conditions of possibility and to outline the specifications of a digital platform that would support this type of collaboration. Again, it must be emphasised that the question of the support platform results from a conception of open science specific to our organisation (OpenEdition Centre) entirely focused on meeting the infrastructural needs of knowledge production. In this regard, we sought to describe and analyse the problems and barriers to collaboration in the different phases of the implementation of the projects, and then to identify a number of key needs that arose from the pairs which are engaged in.

This study resulted in a detailed report published in December 2020 (Caria and Chibois), where its authors put forward six recommendations. Their recommendations express needs that are essential to the ordinary dynamics of the collaborations observed, and are therefore presented as functionalities to be implemented in the planned platform: the management of a community (1), the provision of a common workspace (2), a place for storing data (3) and a dedicated toolbox (4), the provision of assistance with the management of collaborations (5) and a dedicated host organisation that can become an employer (6).

The main results from PLACES

PLACES' final report begins by listing the obstacles encountered by the three experimental fieldwork investigations (Caria and Chibois, pp. 19–66). To summarise, we can classify the obstacles into three categories.

The first category concerns the difficulties that resulted from the different modes of reasoning, investigative procedures and work processes of the researchers and journalists. This is the most practical dimension of the collaboration, requiring participants to adjust their personal work habits to find common ways of acting.

The second category relates to the gap between the fields of knowledge, i.e. the ways of looking at the object of study and "problematising" it. This is a more idiosyncratic dimension, where the partners had to align not only their vocabulary but also their conception of the functioning of society and its structuring dynamics.

The third category brings together all the difficulties resulting from the fact of working at the intersection of distinct professional worlds, which have specific procedures, values, legislation and modes of work organisation not always compatible. This is the most structural dimension of the collaboration, which has forced the partners to face numerous administrative, financial, legal and ethical difficulties. We will go into more detail on this category later, as these are the main issues concerned by the argument of this article.

The report then details the efforts made by the pilot project partners to align their professional practices. Three moments proved to be decisive in this respect (Caria & Chibois, 2020, p. 67–104).

The first was the time of "problematisation" ["*problématisation*", in French] (Lemieux, 2012) of the shared topic, namely the process of translating a societal concern into an investigable research problem. This stage requires that each partner understand the topics of interest of the other, and that they reach an agreement on what topic to address, as well as how to do it. In some pilot projects, this phase has lasted up to ten months.

The second stage was about data collection, when the joint investigation was actualised. Here the reasons that can cause collaborations to fail are numerous and important, such as too great a difference in the way of considering the relationship with sources or of conducting an interview. However, in-depth discussions carried out prior to this stage could help avoid unanticipated divergences.

The third stage is the sharing of the data collected, which raises practical and legal issues, rather than interpersonal ones. Indeed, the fact that the partners do not live in the same city, or even the same country, raises issues of access to the survey materials which can only be partially resolved by online storage tools, due to the GDPR EU legal framework.

These three stages of the process for aligning professional practices are critical beyond the practical and technical success of collaborative research, as it directly affects the partners' perception of their collaboration, and thus their sense of failure or success. It is notable in this respect that, from the point of view of the participants in the three pilot projects, successful collaboration must not distort the professional practices of each partner. On the contrary, they must be respected in their diversity, considered on an equal footing and mutually articulated.

Three conditions emerged in this process of alignment, without which these collaborations could not have been brought to completion: handling the "articulation work", supporting mutual learning processes, and creating a community of practice. The first condition concerns the handling of what we call "articulation work", following the work of Anselm Strauss (Strauss, 1985, p. 2). By this we mean the set of supra-type tasks that the actors of a project must do to make up a coherent project, rather than a sum of scattered subprojects. In a mono-professional context, these tasks are already demanding and time-consuming. In the interprofessional context, when there is also a strong issue of bringing together distinct professional worlds, this work of articulation is even more challenging (Star & Griesemer, 1989; Star & Ruhleder, 1996).

The second condition for the success of these collaborations was the mutual learning process, i.e. the ability of the partners to adopt a learning position with regard to their partner, in a relationship that was as symmetrical as possible. Investigating in partnership meant that each of them had to become familiar with a profession that was not their own, not in order to be trained in it and claim to be a specialist, but simply to articulate their own practice with that of their partner as best they could. For journalists, this meant a better understanding of the methodologies and specificities of the knowledge production process in the social sciences; for researchers, it implied becoming aware of the issues, methods and socio-economic constraints intrinsic to the journalistic field.

It is indeed important to be open to another way of considering and problematising societal issues, and thus to recognise the validity and legitimacy of other ways of doing and thinking. Here, mutual learning is the mechanism that makes the displacement and adjustment of each other's professional practices possible, and it is thus an indispensable prerequisite for the establishment of a horizontal journalist-researcher relationship where each partner is truly a co-producer of knowledge. It should be noted that from this point of view, citizen science is not conceived as a form of scientific mediation, or as a mode of transmission of knowledge from the academic world to other social worlds. It necessarily becomes a two-way interaction.

Moreover, the PLACES project shows that fostering mutual learning transforms not only the relations between researchers and journalists, but also the publicisation of the knowledge produced. The experience of extreme citizen science has changed the perceptions and the practices of the partners of the pilot projects concerning the issues of restitution of the results of their investigations: all of them testified to the fact that they did not write the same articles or make the same podcasts as they customarily did.

The third condition to bring collaborations to full completion was the establishment of "communities of practice" (Lave & Wenger, 1991), that is to say, "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger *et al.*, 2002, p. 4). According to Gherardi (2019) a community of practice "is a network of relations among people, activities and the surrounding environment, in constant communication and interaction with other communities". Without the elaboration of communities of practice, the inter-professional collaborations would fail. Indeed, in order to allow for equal participation in the pilot projects and to avoid one profession taking precedence over the other, it was necessary for all to agree on the procedures and aims of a certain number of activities and on their frameworks. This is what Strauss called an "alignment of practice" (Strauss, 1988, p. 168), which was decisive at two levels.

The first is the level of each pilot project, where the challenge had been to reach a consensus on how to "problematise" a chosen social issue (as seen above), the method of data collection and then to analyse and present the knowledge produced. It is important to note here that it was not only a question of articulating personal preferences or habits, but that norms and values specific to each professional field had to be valued.

The second level is that of the PLACES project's participants as a whole, where the challenge was to create a temporary community to strengthen the links between each pilot project and each participant. The aim was to reduce as much as possible the unknown of this particular form of collaboration, for example by reassuring all the participants regarding the legitimacy of collaborative research or by helping them to invent professional practices adapted to their needs. To do this, we tried to create a collective dynamic favourable to exchange and debate, where everyone could share their experiences and observations with confidence.

There emerges a crucial element. We can see that the community of practice goes beyond the local research projects and encompasses the organisations that surround them. The latter must, as we did, offer resources which are all the more important as the principle of collaboration is not self-evident in an inter-professional context. The objectives in this respect, as we have mentioned above, are meant to avoid structural imbalances between journalists and researchers (e.g. differentiated management of the budget, human resources, compatibility, etc.), to relieve the participants of peripheral tasks, to generate a climate of trust and to enable them to exchange experiences.

These three necessary conditions for collaborations raise a central question: what kind of support is needed to enable not only successful, but also integrated and symmetrical collaborations? We argue that the role of institutions and organisations is central, as they provide the legal and normative framework for all professional activities. They are therefore the actors who must take charge of the work of articulation, promote mutual learning and support the constitution of research collectives.

As we will see now, the Hypotheses.org platform, as a service and not only as a technical device, has been the means by which we achieve these goals in the case of PLACES. It

contributed to explore and, to a certain extent, provide support for concretising the three conditions outlined above, as well as to actualise a first level of integration of practices and epistemic cultures for the implemented extreme citizen science research.

Hypotheses.org as a tool for citizen science

Founded in 2009, the Hypotheses.org academic blogging platform is one of the four platforms constituting the OpenEdition research infrastructure, which also includes a journals platform (OpenEdition Journals), a books platform (OpenEdition Books) and an academic events and announcements platform (Calenda). Run by OpenEdition Centre, OpenEdition infrastructure is a public non-profit initiative supported by leading research and higher education institutions (the CNRS, Aix-Marseille University, the EHESS and Avignon University) whose main objective is to support and promote open access electronic resources and academic information in the humanities and social sciences.

Hypotheses.org is specifically dedicated to the social sciences and the humanities, providing blogs - also called "open electronic notebooks" – in open access, whose content is not aimed exclusively at specialists and may be of interest to a broad readership. Hypotheses.org is based on the free and open-source content management system WordPress, adapted to a multisite installation that has to provide information system security and stability for several thousand active blogs. The whole platform registered 17 million visits in 2020.

The Hypotheses.org's openness to experimental writing practices, freed from the formalised editorial spaces and workflows of scientific journals, coupled with the use of the WordPress content management system, allows it to take stock of the structural plasticity of blogs. As Dacos and Mounier, the initiators of Hypotheses.org platform in 2009, put it: "the scientific blog should be defined as a multi-purpose communication tool that researchers can use in the different dimensions of their work" (Dacos & Mounier, 2010). Indeed, this platform provides an environment open to a wide variety of uses, as Poupardin and Faury have shown (2018): "digital environments, direct communication or mediated communication, based on "disintermediation", accompanying research-in-the-making, a place of living and writing, a permanent seminar, a place of "quiet" conversation - new form of the old *disputatio*, a "missing link" or blind spot in human and social science research".

Notebooks, either electronic or not, are similarly parts of larger sociotechnical dynamics that are central to the production of scientific knowledge (Latour & Woolgar, 1979). But, blogs have some specificities (Mortensen & Walker, 2002): they are "tools with which to think about our research, its values, connections and links to other aspects of the world" (p. 251), they are "borderline [spaces] between the private and public" (p. 257). Moreover, when they are aggregated in a unique platform, the latter offer visibility and recognition to a community of academic bloggers, and it creates a reflexivity effect that allows bloggers to recognise themselves as being part of such a community, and eventually advocate the role of the blogging practice for academic purposes. The character of "publicity" is of high importance here. Thanks to the comments feature and the possibility of hyperlinks by which they are densely interwoven, it makes blogs conversational spaces that anchor the researchers in the "public arena" (Mortensen & Walker, 2002, p. 249) and creates communities (Dacos & Mounier, 2010, p. 101).

From this point of view, the Hypotheses.org platform is not only a technical platform, providing opportunities and constraints, and it is not only this infrastructural layer of the managing of the single blogs. It has to be considered as a sociotechnical device, i.e. a chain of sequences, designed to qualify or transform states of things by means of an assemblage of material and linguistic elements (Dodier & Barbot, 2016), including a social dimension.

The initiators of Hypotheses.org expressly sought to gather and interconnect scattered initiatives of researchers and groups of researchers in the SSH fields, first in France and then in Europe, to make them benefit of a "platform effect": enhancing the visibility and discoverability of their work, as well as facilitating the building of a community united around a common practice - the academic blogging. From this point of view, Mounier and Dacos have taken the counterpoint of a more widely shared conception of scientific blogging, according to which blogs are mainly spaces of "personal knowledge management", a point recently endorsed by experienced academic bloggers to argue on the decline of blogging practice (Carrigan, 2022).

Thus, the Hypotheses.org platform, with its team of community managers and its community of users, thrives within a whole ecosystem designed to provide an international, open access, and multilingual space dedicated to scholarly communication in the social sciences and the humanities. Furthermore, by its design, the platform allows the gathering of communities of interest and communities of practice, a possibility that is fostered by a community support based on three pillars: free training, free documentation, and dedicated mailing lists for the members of each linguistic community.

These features led us to think that the Hypotheses.org platform may well play a central role in projects dedicated to experimenting with extreme citizen science research practices, on an infrastructural level. We saw it as a privileged mean to increase what Göbel *et al.* (2022) called the "cooperation capacity", that is to say our "ability […] to establish connectivity and relations - inside [our] heterogeneous consortia as well as between [us] and other actors outside - to generate scientific knowledge".

In the PLACES project, it has been the main communication channel, through a dedicated common blogging space (https://places.hypotheses.org) where all the project participants were gathered: both the journalists and researchers involved in the pilots and the researchers involved in the study of the pilots' ongoing collaboration. Both the blogging tool and the blogging practice, providing a space that can be viewed as a permanent "training" space (Dacos & Mounier, 2010, p. 102),

allowing experimenting and making the experimentation visible by the bloggers themselves, contributed to the premises of the community of practice sought by the project designers.

The uses of blogs in extreme citizen science, in practice

To succeed in gathering a first community of practice, the PLACES project needed someone with knowledge of the platform, its uses and possibilities, and the effects that its sociotechnical framework allows. The recruitment of the co-author of this paper, Jonathan Chibois, made extensive use of his personal research notebook on Hypotheses.org while conducting his PhD research - and was thus a member of the Hypotheses.org community - was an opportunity to fulfil this need. By practising himself the showcasing of research-in-the-making and building knowledge networks - and embracing its benefits — he directed his efforts towards facilitating the interactions among pilots' partners and their diverse audiences. Thus, he ensured there would be, for the PLACES blog, coherence with the overall aims and objectives of Hypotheses.org, and Jonathan's additional role - we shall say: his "infrastructural" role - as a micro-community manager, who encourages the development of a common blogging space that allows for pilots' member to notice the progress made by everyone (internal aim), as well as showcasing the project for the participant's respective professional worlds (external aim).

Following the aim of mobilising Hypotheses.org for citizen science projects purposes, an objective became to build the premises of a collective dynamic starting from the PLACES project's participants. This translated into a top-down/pre-designed editorial project that was not negotiated with pilot's participants, all the while staying open to their suggestions and contribution, with no hard constraints imposing them to accept contributing with contents. This editorial project drew on the principles of interactivity (facilitating the creation of links among the PLACES pilots' participants), collaboration (supporting working synergies between geographically distant participants) and reflexivity (publicising the conceptual background, intermediate hypothesis and results) (Caria and Chibois, p. 14).

Even though blogging, whether academic or not, is a far more recognised practice than ten years ago, it still remains a side practice for many practitioners, either in the research professional world and in the journalistic one. Reluctance from the participants to share their intermediate results and reflection-in-the-making illustrate common concerns about "exclusivity" (namely, more or less conscious intellectual property concerns), about mastering one's own digital identity and time constraints implying major prioritisation of tasks to attain the pilots' goal. These common concerns underpinned the additional layer of difficulty related to the fact that a community of practice around extreme citizen science in the SSH did not exist on Hypotheses.org before PLACES began.

In fact, although participants were constantly invited to participate, it was hard to concretize their commitment in the PLACES blog. We faced difficulties and delays, when asking the three pilots' members to participate in the writing of "behind-the-scenes" posts, and offering a glimpse into their collaboration. Only one participant finally took the initiative of publishing a part of the pilots' results on the blog, as an extension of the article published into her media outlet.

There seems to be a contradiction here: on the one hand, pilots' participants expressed somewhat a feeling of isolation, and their expectation for more collective sociability; on the other, they seldom seized the interactive opportunities of the blogging tool, and actually only when pushed by an external initiative (Caria and Chibois, p. 125).

To explain these difficulties, let us bear in mind that all the journalists committed to publishing journalistic output with the media they were working with within the frame of the PLACES project, so they already had the duty to provide some deliverables. Then, they shared with their pilot mates-researchers a reluctance, in view of a benefit-effort balance: namely, the benefit they could earn facing their peers, compared with the time they perceived having to spend on blogging. This reluctance was not overcome within the timeframe of the pilots. Introduced once the project had begun, the demand to take hold of the blogging space did not find a place in the workflow process that the participants had planned (Caria and Chibois, p. 127).

To overcome these difficulties, we suggested working within a collective dynamic that we called "accompanied posts" plan. The principle was to give a third person the role of editorial secretary, to relieve the pilots' partners of the most difficult tasks of writing the posts, to support them in their discovery of the Wordpress interface and to gradually introduce them to the principles of scientific blogging. We chose the format of semi-directive interviews, conducted and written by a member of the project's coordinating team, then re-read and revised at will by the given pilots' pairs before publication. In doing so, we created a collaborative process through several steps: it started with the interviews, continued with the transcription and writing of the posts, and finally with the sharing of the publication with the other pilots.

Taking stock of the PLACES experience, another framework was set up for the current COESO project (https://coeso.hypotheses.org), in order to push forward the building of a community of practice around participatory research and extreme citizen science within the SSH. Within COESO, each pilot committed, by the project design, to feeding a dedicated blog for their common research, independent from the project level blogging space. Each one of the pilots' blogs is being used as a research tool and as a research communication tool, and it is directly tackling the challenge of uptaking the blogging practice within a collaborative research framework, thus involving non-academic stakeholders in every phase of the research process. Additionally, the participants integrate the well-established Hypotheses.org academic community, with a strong identity and with precisely defined quality control processes, through a research methodology - extreme citizen science - that is not yet greatly present within the platform.

With this dedicated space, thus, also comes the full responsibility of their editorial space, for the writing, editing and publishing of their content as well as free latitude for their editorial project, within the editorial perimeter of Hypotheses.org, yet without having to share the space of the COESO project level. A dedicated community manager has also been hired to assist the pilots' participants in the handling of Hypotheses.org for citizen science-oriented purposes, in animating their projects' blogs and in facilitating the circulation of information between the different pilot projects (Fanget & Smaniotto, 2021). On their side, some of the current COESO pilots show a more proactive use of the blogging space. They are using it mainly as a means to disseminate information (ex. sharing upcoming activities, introducing the questionings, the sources mobilised, etc.) around their project. They are also summarising and reporting on their activities, including in these summaries a more or less developed degree of reflexivity or contextualization (this may include pieces of field notes or internal discussions, and initial hypotheses to be tested). All these uses are in line with Poupardin and Faury's typology (2018) seen above.

The role that a blogging platform plays in building communities is highlighted again by the fact that most of the pilots' participants see the blogging activity first as a means of internal communication, ensuring a proper follow-up of the research, for those participants who are not involved in all the project's activities. Secondly, the pilots' partners of COESO, and even those of PLACES at the end of the "accompanied post" plan, consider that the blogging activities help to facilitate further cooperation (for ex. by sharing intermediate analysis and progressively building a final research output, will it be conjoined among the partners or not), as well as to showcase the work to the other pilots. Thirdly, by showcasing their activities on the blog, the participants of both projects are led to structure and somehow formalise their approaches, as well as share their solutions, both technical and practical, with other participants.

The role of infrastructures in the building of a community of practice

We have seen that with this use of Hypotheses.org, it is not the blogs *per se* that are creators of collective dynamics, or of community, but above all the fact that they are inserted and integrated in a larger sociotechnical ecosystem - an insertion and an integration that has not to be taken for granted, and can be facilitated through specific actions. There is what we call a "platform effect" that allows individuals to acknowledge that they belong to the same groups, in the sense that they use similar practices for similar purposes. At this stage, the connection between the infrastructure dimension of research activities and the ordinary researcher's practices is conspicuous.

In the second part of this article, we will develop this point by first looking more specifically at how the Hypotheses.org platform has helped to overcome concrete obstacles within the performed extreme citizen science projects. We will then show how a detailed understanding of the needs of this type of project should be taken into account in the design of communication platforms, which will lead us to address the conjoined issues of the governance of the infrastructures, as well as the governance of citizen science projects.

Making communities of practice glaring

As discussed above, with PLACES and COESO a new practice was put into the Hypotheses.org space, and within its editorial perimeter, pushing forward the research-society relationship, beyond the common science communication practices. PLACES' final report presented "as obvious" (Caria & Chibois, 2020, p. 13) the opportunity to use a dedicated blog in the Hypotheses.org platform, integrated with this aim of reporting and rendering visible the goings-on of the pilots' field research. If it was indeed obvious for the project initiators, it was nevertheless necessary to introduce, convince and train the pilots' participants to using the academic blogging space as a means not only for communicating about their research results, but also as a means to facilitate their own interactions, as well as the interactions with their differentiated audiences, and as a means to recount and perform their research.

Indeed, the pilots' participants must overcome a certain number of obstacles to succeed in their blogging collaboration, which may be difficult to achieve on one's own. The experience of PLACES shows, as earlier research observed (Baudry *et al.*, 2022), that "users" do not always spontaneously appropriate an infrastructure provided to them, nor do they make appropriate use of it straight away. In order to become users, they often need to be accompanied in their discovery and handling of the tools and services offered. Furthermore, this need for support is in line with the results of recent large-scale studies which draw our attention to the fact that citizen social science projects tend to involve not only scientists and citizens, but also many more types of actors, such as staff of the various partner organisations, municipalities, universities, etc. (Göbel *et al.*, 2022). This implies the necessity to involve what we suggest calling a "third party", who is entrusted with this specific mission of assistance and support, and whose role and modes of action must be taken into consideration. This "third party" action could be mediated by a socio-technical device and it constitutes a particular form of articulation work: in the PLACES case, it led to take up three main challenges.

The first challenge for the pilots' participants consists in defining their common work, and thus to get the pilots' pairs to align their practices as early as possible in their collaboration. Indeed, defining a shared way to approach the societal issue they wish to tackle together - what above we called "problematisation" - demands a huge investment in terms of time and energy that must be acknowledged, accepted and scheduled. The awareness of this challenge inherent to interprofessional collaborations facilitated the project management, enabling participants to better prepare for and cope with it.

In our case, the intervention of a third party, i.e. the coordinating team, was fundamental, not to act as a mediator or to set a specific pace for the collaborative dynamic, but to bring the participants face to face with these challenges as quickly as

possible. In other words, its role was more that of raising awareness than bringing them towards a predefined path. This very first moment of defining the research question is crucial to allow the collaboration to reach a higher degree of robustness by making the participants deepen their acculturation of their partner's professional world.

We learned that one effective way of overcoming this difficulty is to bring the participants to narrate their collaboration and to formally present their common project, in its social as well as research objectives. This narrative work was in this case performed through the writing of blog posts. The negotiation of format, vocabulary and concepts used, and what needs to be said or concealed, generates discussions rich in explanations and clarifications from both sides.

The second challenge is to articulate the professional cultures, and thus find some compromise with the divergences that exist between the socio-professional worlds on the organisational, legal and financial levels, as well as in matters of the working rhythm and working conditions. As we have seen above, without specific support, the participants in an interprofessional collaboration are likely not only to see their working conditions out of step, but also to spend much time and energy on secondary administrative tasks. Given the structural gap between the two professional worlds, there exists a real potential for the failure of collaborations.

A first consequence of this structural gap is the overload related to peripheral work, and therefore the "dispersion" in one's work (Datchary, 2012), which the participants have to face when bridging the gap between the two worlds. On the one hand, they are forced to solve numerous small administrative and practical problems, such as having their employer recognise the need to adopt a different working rhythm over a given period or to negotiate computer access rights with their partner. On the other hand, they are forced to invent solutions to situations that are rare, poorly documented and for which resource persons are hard to find, such as convincing an employer of the legal validity of an employment contract that is not recognised in a given professional sector. This requires participants to become familiar with areas outside their initial field of competence and to acquire skills in labour law, accounting, project financing, etc.

A second consequence of this structural gap is the risk that one of the professional worlds overrides the other, thus generating an unbalanced distribution of responsibilities between the participants, and an unbalanced recognition of each other's expertise. The issue that may arise is thus that of "governance", namely how they organise their actions as a collective, and distribute the roles to guide their movements. In an extreme citizen science programme, a balance is expected between the participants regarding the governance of the common project. When this balance is not maintained, our experience shows that one of the participants tends to disengage and consider himself or herself only as an occasional "expert" or "consultant".

The third challenge is in line with the previous ones, as it concerns each partner's feeling of being "legitimate" once it comes to activating her/his expertise for the project's sake within the project management, acknowledging everyone's field of expertise and above all, acknowledging the respective epistemic cultures. Thus, this raises the question of the partners'' positions and professional identities, which must be discussed, clarified and stabilised.

In the COESO project this question became visible when the problem arose, for instance, of who would have the "rights" to write what and how in the Hypotheses.org academic blogging space, even though no formal questioning about legitimacy derives from the platform design itself. Indeed, the platform design allows citizen science projects, as far as one is only asked to provide a clear editorial and scientific project description to open a blog, and at least one of the leading editors of the blog must have an academic affiliation.

Nonetheless, this issue even within a group of partners formally engaged in a joint citizen science endeavour highlights the siloed condition of knowledge production, sharing and dissemination that practitioners and researchers face. It is linked with the respect of each other's epistemic cultures, i.e. the different ways to know and build knowledge.

Understanding community needs, designing platforms

Now, let's take for a moment a step aside from the PLACES and COESO projects to take a look at the main findings of another study reflecting on collaborative research activities that can be considered as falling under the "citizen science" umbrella term.

Drawing on the analysis of three case studies implementing co-creation/collaboration research activities involving, along with researchers, public officials, staff of a not--for-profit association, or indigenous community leaders, Okune *et al.* (2019) highlight the need for more inclusive knowledge infrastructure. The three cases come from the Open and Collaborative Science in Development Network (OCSDNet) that was carried out between 2015 and 2017. Building on an intersectional approach to the study of the materiality of digital infrastructures (Noble, 2016), the authors shed light on several socio-political elements that are embedded into infrastructures: the centrality of network building, together with the need for alignment and consensus making; the fact that the policies surrounding infrastructure development (including openness) cannot be taken for granted, and there is a need to differentiate the options (without leaving behind the principles on the way); the need for inclusive policies, and for models of governance organisation; the necessity not to take for granted the models of agreements for sharing knowledge and/or data. Full acknowledgement of these socio-political elements, according to Okune *et al.*, leads to recognition that these elements are "key to making or breaking (the infrastructure) usage, and negotiating its inclusivity" (Okune *et al.*, 2019, p. 111). In their own words: "Both users and creators of infrastructures have complex, heterogeneous and (at time) conflicting needs and identities

which should be accounted for in the design of knowledge infrastructures" (Okune *et al.*, 2019, p. 114).

The lesson we take from reading their contribution is that if the infrastructures are not only technical, the users' needs are not either. We reached a similar conclusion in the PLACES project. For some of these needs, solutions already exist, in some cases for many decades, to support joint collaborations between researchers and other societal actors.

Firstly, it appeared necessary to provide projects with working space, and tools independent of their respective employers and professional worlds, e.g. meeting rooms, computer and multimedia equipment, a digital working environment, and data storage space. Science shops, fablabs, and the common working spaces that libraries provide, as well as digital working spaces provided mainly by private organisations, and public and private storage solutions, fulfil these needs.

Secondly, it appeared useful to provide resources where the knowledge, methods, obstacles and solutions found by successive collaborations could be gathered in and accessed from a documentary database open to all. It appears useful as well as offering training and support services in collaborative research for novice participants. The growing number of citizen science platforms allowing the participation in citizen science activities, or showcasing these (Liu *et al.*, 2021; Severo *et al.*, 2022; Wagenknecht *et al.*, 2021), meet this need in the digital environment, by gathering resources, sharing best practices, building cumulative knowledge about ongoing projects, how they are implemented or how they could be implemented in given situations. Some of these platforms also include training modules. And as we presented in the first part of this paper, one of the pillars of Hypotheses.org platforms consists precisely in providing, along with documentary resources, free training on a regular basis.

Thirdly, a dimension less explored when it comes to describing citizen science endeavours, which appears more clearly with small teams and high intensity collaborations like the ones of PLACES and COESO, is the one of the administrative, financial and legal issues the participants coming from different professional worlds have to tackle. This evidences the need for expert services or documentation on these topics, as well as for an information monitoring service on funding opportunities.

All this justifies the crucial role that a dedicated team could play as a third-party, i.e. the human resources dimension of an infrastructure, which tends to be entirely neglected even in the case of infrastructures dedicated to sustaining collaborations. Indeed, we consider that an extreme citizen science partnership includes third actors to help the participants reach their collaboration goal. It appears in the PLACES and COESO projects that such a support role is indispensable and makes professional collaborations far easier. To be efficient, it should be noted however that this third actor must act *from* the backstage, while its action may be perceived as evident and natural in the front-end by the participants. Indeed, to minimise the risk that it interferes in the governance within the collaborations, maintaining its main activity on a "supra" scale (Strauss, 1985, p. 2) is necessary.

In other words, the purpose of these human resources is to take up the "articulation work" (Strauss, 1985) at the general level of the infrastructure, i.e. to work towards the unity of collective activities beyond their heterogeneity. That means, for a particular platform, to help its users get a grip on it and to ensure its technical development. We have identified two complementary modes of action this sociotechnical role could take shape.

Firstly, this third-party may act through a platform aiming to take in charge the ordinary process of the joint research project, which must then be conceived as a service offered to facilitate collaborations. Here, the third-party role is favourably performed by the sociotechnical mediation - i.e. through predetermined frameworks, pre-established procedures and pre-designed tools provided to the participants - which has the benefit of making its action effectively unobtrusive. The logic is not to oversee the processes and frameworks of collaborations but to guide their participants in a plurality of directions that have been proven to work, and help them to appropriate the services it best fits them. The human presence can take the form of a "community manager", whose mission would be to coordinate a broad community of several collaboration projects by implementing communication, training and supporting actions.

Secondly, this third-party may act as an "umbrella organisation" that takes in charge the funding management and allows the participants to have uniformed and favourable working conditions. Yet, the purpose of such an umbrella organisation should also be to put into practice the knowledge around interprofessional collaborations' needs: for example, it should be able to fund the huge time-consuming and energy-consuming preparatory stages of such projects, for which participants are otherwise obliged to take the risk of unpaid work. Here, the support role would be more determined, in the sense that it would offer participants a set of services aimed at releasing them from tasks pre-identified as bothersome and requiring expertise (such as negotiating employment contracts, defining legal frameworks, administrative management, etc.). On this organisational side, the human presence could take the form of specialised staff, acting as advisors on specific issues (legal, financial, etc.), as coaches offering advice on collaboration problems, and even as guarantors, if necessary, when coping with an administration or a funder.

However, this support role carried out by a third party, whether mediated by a platform or an organisation, both in human and technical terms, does not grow spontaneously within the infrastructure. It must be thought out, planned, financed and implemented. But in the name of what values and aims should the infrastructure be managed? This question leads directly to concrete considerations about the design and governance of

this supporting role, i.e. the design and governance of the infrastructure. From our point of view, as it will be argued in the last section, design elements are not only symptoms of a given governance, they can also be instruments of this governance.

Design and governance of infrastructures for citizen science

Another lesson from Okune *et al.* (2019) is that there are no standardised users and knowledge infrastructures – even the publicly funded ones do not serve all users equally. Consequently, in the design of an infrastructure or a platform, particular attention ought to be paid in providing benefits for all the potential users: this is of paramount importance when the possibilities of asymmetries – and thus imbalance of forces among the partners, are high. Thus, attention must be paid during all the design phases of an infrastructure, and for all the infrastructural dimensions, at how it manages to gather users as well as their possible interactions, which resources they provide, and, as a result, the practices they are more likely to support and shape.

The definition of design we are mobilising is inspired by the work of Ezio Manzini (2015), who reflects on the links between design - intended as a general practice, and social innovation. Believing that the whole society is a huge laboratory of sociotechnical experimentation, Manzini sees "design" as a term gathering a diversity of activities, all of which has the aim of coming to terms with an environment, in order to collectively orient it, in a renewed balance with more traditional top-down approaches. The design practice core characteristic is, according to Manzini, bridging the gap between social systems and technical systems.

For instance, in PLACES and COESO, which are mission-oriented projects towards the development of a platform envisioned to sustain, showcase and help find funding for SSH citizen science activities, the question of "legitimacy" mentioned above (section "The main results from PLACES") is not a side concern in this respect. Indeed, pilot partners need to see their epistemic culture fully acknowledged and respected, in order to achieve an integrated collaboration where an equal legitimacy to act is allowed. The epistemic cultures of professional worlds are framed by specific methodologies, ethics, organisational structures and timeframes of work that are different. How these aspects achieve balance to allow a collaborative project implementation, depends on how the partners decide to share responsibilities and jointly organise their work (what we identify with the act of "govern"). On this matter, the development of the COESO platform, called "Virtual Ecosystem for Research Activation" (VERA), takes into account not only the technical needs of the users, but first and foremost the challenges that the interprofessional collaborations have to face in order to succeed.

Drawing on our observations of the pilots at work both in PLACES and COESO projects, the question of the internal balance of their collaboration, enveloped in the several dimensions of the articulation work we listed in the first part, appeared paramount. The question on how to maintain this equilibrium raised the issue of governing, i.e. the way in which the parties organise themselves, their actions as a collective. Indeed, we use the term "governance" to refer to the act of leading a collective, taking the responsibility to tell what is the "right" way to proceed. This leading role can be distributed among the partners in a fluid way, following specific phases and situations of the collaboration, each one guided by a variety of principles or criteria (sharing, justice, participation, efficiency…).

In the first part of this article, the description of the way in which the parties organise themselves and their actions as a collective, has been framed through the language of articulation. Indeed, the way we describe the internal balance of the collaboration, which terms we employ and how they are perceived by the readers/listeners, is part of the question. "Balance of power", "decision-making processes", "governance", "govern", etc. are words carrying a long tradition that orient our representations of collaboration, introducing for instance representation of power relationships and/or of self-interest (Chignola & Duso, 2008). There is a price to pay for citizen science practice in using such terms as if their meaning could be taken for granted, or as if their use were not burdened with representations of a necessity of "power" relationships and hierarchies among partners. Starting from the questioning of the internal balance, and of the projects' governance needed to preserve it, we can now ask: how can an infrastructure uphold the relationships of a project's governance?

The Science and Technology Studies literature shows that artefacts (or technical objects), from the least to the most sophisticated, have no intrinsic neutrality but are strongly political (Winner, 1980). In the field of citizen science, this question of the politics of artefacts directly concerns the governance of knowledge production, research strategies and funding policies. But the same body of literature also shows that a collaborative infrastructure generates effects that are not completely envisioned and mastered by those who designed it (Star & Ruhleder, 1996): to a certain extent, depending on the appropriation by the users, by the changes in the environment, an infrastructure can elude its initial design and may open up new potentialities.

For citizen science purposes - that are guided by the will to make research and society work together – it is important to keep in mind that it is necessary to beware of any bias potentially embeddable in the infrastructure. Indeed, it could give a predetermined form to the internal relationship of the collaborations, because the governance within the pilots can be influenced by the design of the infrastructure (design that includes the infrastructure own governance).

In the case of open infrastructure dedicated to citizen science, the question of the transparency of decisions and of the opening of the governing organisations, are of utmost importance. Regarding the transparency of decisions, the question of the particular values and aims of this third party actor must be addressed, to make explicit the existence of intentions

and preconceptions about the form and purpose of the collaborations. The transparency of the development of policies of such infrastructures seems to be a protective requirement so that everyone may gauge the ethical foundations underlying the governance decisions, the relevance of the strategic choices made, and thus the nature of the knowledge produced. The question of the opening of the governing organisations highlights the inevitably normative nature of the third party's infrastructure design activities, due to the organisational role assigned to it. This is particularly important in the context of citizen science, which aims to enable collaboration between a multiplicity of actors, who belong to different socio-professional groups, and with potentially divergent needs and objectives. For collaborative projects to be as diverse as possible, it is significant that a policy of openness is enforced at the governance level of the supporting infrastructure.

The design of a platform for supporting extreme citizen science should allow a diversity of project governance configurations, and allow all participants to become familiar with the possibilities available to them, in order to give all participants room for reflexivity and fair choice (here comes the role of advocacy and the technical feature of making room for diversity). In this respect, design is a route to solve political issues.

Conclusion

In this article, we have argued that extreme citizen science projects can be conceived as interprofessional collaborative relationships. The argument is based in particular on a case study of three examples of extreme citizen science between journalism and research. This approach offers valuable insights into a certain number of issues and problems regarding the implementation of this type of project, all in connection to the difficulty of bringing together practitioners from distinct professional worlds, whatever they may be. From this perspective, supporting and allowing for citizen science projects to be successful requires helping participants to resolve the multiple barriers that prevent them from aligning with each other in terms of their professional practices, their goals, their ways of posing the research problem - i.e. "problematising" - and their working frameworks.

To achieve this objective, we have shown the interest and relevance of acting at the level of the infrastructure, understood as a social and technical ecosystem from which citizen science projects are likely to benefit - if properly supported - in order to achieve their objectives. The primary aim of such an infrastructure is to enable participants to bridge the gap between their professional cultures by facilitating the creation of a temporary community of practice of their own. We have identified two complementary modes of action through which this infrastructural support can effectively act: providing a platform and an umbrella organisation. However, in order to achieve the goal of extreme citizen science, it is important to ensure that the participants in the collaborative project are able to work together in a shared equilibrium, which implies requirements for openness and transparency at the infrastructure level. It is in this respect that the continuous design activities of the sociotechnical systems play a fundamental role.

Finally, we wish to emphasise that bridging over distinct professional cultures and bringing the participants to mutually align their goals, practices and working framework is an ambition that is part of a particular conception of citizen science. This implies both that non-academic actors acculturate themselves to the specific modes of scientific knowledge production, and that academic researchers open up to other modes of knowledge and recognise their validity, in a symmetrical relationship. Thus, in this approach, citizen science does not aim so much at involving citizens in projects conducted by researchers within the framework of a policy of scientific mediation. On the contrary, it aims to erase as much as possible the barriers that separate them in order to bring them together to produce, together, new knowledge.

Ethics and consent

No ethical approval is required for this manuscript. The projects discussed in the manuscripts received ethical approval by the relevant institutions.

Data availability

All the data underlying this theoretical reflection are available as part of the article and no additional source data are required.

However, some additional information about the PLACES project can be found in the project report published at its term (Caria & Chibois, 2020).

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Marta Severo
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The paper presents the results of the research project COESO. This project aims at applying an extreme citizen science approach to professional collaborations. It considers the case of the collaboration between researchers and journalists through three case studies.

Moreover, it presents the use of a digital platform to manage the collaboration among actors.

Globally the paper is well written and clearly structured.

The topic is interesting and it crosses current research trends.

Methods are coherent and well justified.

We can suggest three changes that could reinforce the global argument of the paper:

Better justify why these cases have been considered extreme citizen science and not collaborative practices between professionals (researchers are also professional). It is not very clear to me what is specific to extreme citizen science in these cases. More literature can be cited to make clearer this distinction between collaboration between professionals and citizen science.

Better justify why a digital protocol and a digital platform is necessary to build a collaboration between three couples of people.

Better justify the use of the term community of practices. Two people are enough to use the term community? I'm not sure, the text could better explain how just two people can be a community.

Is the work clearly and accurately presented and does it engage with the current literature?
Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Not applicable

Are all the source data and materials underlying the results available?
No source data required

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Digital communication, digital methods, cultural participation, cultural heritage, social media, digital traces, digital participation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 01 February 2023

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Muki Haklay
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I believe that this paper has a lot of merits and should be developed further. There are some fundamental issues and some lack of engagement with the existing literature that is a source of concern.

Let's start with the most obvious challenge of this paper - the claim that it is describing a case of extreme citizen science. Yet, in the definition by Haklay 2013, this practice is described as "collaborative science is a completely integrated activity, as it is in parts of astronomy where professional and non-professional scientists are involved in deciding on which scientific problems to work and the nature of the data collection so it is valid and answers the needs of scientific protocols while matching the motivations and interests of the participants. The participants can choose their level of engagement and can be potentially involved in the analysis and publication or utilisation of results. This form of citizen science can be termed ‘extreme citizen science’ and

requires the scientists to act as facilitators, in addition to their role as experts. This mode of science also opens the possibility of citizen science without professional scientists, in which the whole process is carried out by the participants to achieve a specific goal." Moreover, a further definition is available on the Extreme Citizen Science group website: "Extreme Citizen Science (ExCiteS) is a situated, bottom-up practice that takes into account local needs, practices and culture and works with broad networks of people to design and build new devices and knowledge creation processes that can transform the world."

The paper is describing a collaboration in which the non-professionals are inherently required to move towards the world of science - in this case, to use the platform that was created and is run by (social) scientists. At least at face value, this is not a situation that can happen "without professional scientists". Moreover, the problem did not emerge from the non-professionals but through deliberations between scientists and non-scientists. Therefore, the first question for this paper is: to what degree did the non-professional participants (journalists) lead the project? The paper hints at a certain deference towards scientific expertise, and as noted above, the infrastructure that is at the centre of the paper is also aimed at scientists. If so, isn't this much more "Participatory science" in Haklay 2013?

So this is not to say that this is not an example of extreme citizen science, just that this must be explained and justified – including explaining what is the authors' interpretation of the concept, which does not need to be in line with other interpretations.

Next, similarly, there is a question in what way this is citizen science? The journalists are professionals, and therefore this is an example of transdisciplinary collaboration and not citizen science?

Based on these two issues, it will be useful to introduce to the reader in a much more detailed way to the reasons why this project is considered citizen science (e.g. by using ECSA principles or characteristics) and then justify what makes it an extreme citizen science.

Next, I would suggest the authors pay attention to what their use of the literature says about the structure of the paper and what should be introduced to readers. Especially standing out is that towards the end of the paper, Okune et al. is taking a central place, but it is not introduced earlier, and similarly Manzini. If they are central to the analysis, shouldn't some of the theoretical framing be discussed and appear earlier?

Another issue is the way infrastructure, which is central to the discussion, is handled - maybe it is worth considering a section which will bring together the different literature that is spread across the paper (e.g. Latour, Star, Severo, etc.) and provide a clearer discussion in one place? I would also recommend looking at the work of Jennifer Gabrys [1,2,3], who looked at the context of infrastructure within environmental sensing activities. Her insights into infrastructure within civic action are highly relevant to the extreme citizen science concept, so it is worth looking at it. You can also look at Rey-Mazón *et al.*[4] on Public Lab for another community of practice in such an area.

This brings us to another aspect - the degree that the community of practice concept is suitable for this context and type of work. There are several papers on communities of practice in citizen science, such as Sbrocchi *et al.* 2022[5] or Liberatore *et al.* 2018[6]. It is somewhat expected that a

comparison with these other CoPs can be useful.

Finally, I think that for a reader who is not from the social sciences, it is valuable to provide a better discussion of the unique aspects of citizen social science - for example, from Purdam 2014[7] or Mayer *et al.* 2018[8]. There is a general sense that this topic is not covered well enough.

What this all indicates, and that is something that explains the complexity of this paper, is that multiple concepts are all being brought together: citizen science, citizen social science, extreme citizen science, platforms, infrastructure, community of practice... maybe the paper could benefit from bringing clarity by reducing or removing some of these? For example, is the community of practice concept central to the understanding of the rest of the discussion, or is it something that the paper can do without?

On a different matter, I would ask the authors to consider the balance between PLACES, which is discussed in a lot of detail, and COESO which does not receive much space. Can you consider how to balance the description (e.g. in the extent of word count given to each?) This is not necessarily the right thing to do, and it might be that it's important to discuss PLACES in more detail to explain the infrastructure, but at the moment the details go down to a specific case, which does not give enough space to the other project. It also might be the case that as the focus is on the platform and the infrastructure, only limited information is needed about the cases. This is worth considering.

Notice that all the above does not ask for specific changes or, as some reviewers do, ask you to fix this or that. Rather, this review is aimed at suggesting where things are unclear and where the rest of the literature can provide a different light on the issue, and therefore consider if you need to take the issue into account within the length limitation of a paper.

Other minor comments:

It is worth explaining to the reader what is the nature of the media partner - 20 minutes is a very different proposition than a broadsheet newspaper and the reader is not necessarily familiar.

Secondly, in the discussion about the engagement of scientists with social media and blogging in general, it is worth looking at work such as Zhu and Purdam 2017[10] in "First Monday" or the work of Golumbic et al. 2017[11] on scientists' views on citizen science. Both would strengthen your claims.

Thank you for an interesting paper that highlights the role of software infrastructure in citizen social science activities and hopefully, the comments are useful

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Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Not applicable

Are all the source data and materials underlying the results available?
No source data required

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Citizen science, participatory research

I confirm that I have read this submission and believe that I have an appropriate level of

expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Reviewer Response 25 Aug 2023

Mordechai Haklay

After listening to the COESO podcast series "exploring citizen science" (https://www.europod.eu/podcast/exploring-citizen-science/) and reflecting further on my comments, I would like to update some of the comments in my review above.

Within the specific context in which the projects described here operate there is indeed a case to call the activity "extreme citizen science". However, this needs to be explained and justified briefly. The issue that is of high importance here is the worldview. For the researchers who are involved in these projects, this was a level of engagement and intervention in the way that they conduct research to a very high degree. They had to relearn how they developed research questions and understand the approach of journalists so they could consider how to carry out social science research. I am much more accepting that while it is not at the level of a community, this is a demonstration of an individual participating in a very high level of shaping academic research.

The second point that needs revision is the participation of professional journalists. The ECSA Characteristics of Citizen Science discuss specifically that the participation and recruitment of professionals can be considered citizen science, as long as there is an explicit appreciation of what makes the activity a citizen science activity. This is a conceptual framing and one that requires all stakeholders to appreciate and accept that it is a citizen science activity. Again, the podcast makes it clear that this was the framing of the project and the activities and was also accepted by the participants.

My other comments are relevant and I think that the paper can be improved with some minor changes.

Competing Interests: No competing interests were disclosed.