Citizens for Science and Science for Citizens: The View from Participatory Design

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ABSTRACT
The rise of citizen science as a form of public participation in research has engaged many disciplines and communities. This paper uses the lens of Participatory Design to contrast two different approaches to citizen science: one that puts citizens in the service of science and another that involves them in the production of knowledge. Through an empirical study of a diverse array of projects, we show how participation in citizen science often takes the more limited forms suggested by the former approach. Our analysis highlights the implications of limited participation and demonstrates how the CHI community is uniquely positioned to ameliorate these limitations.

Author Keywords
Citizen science; participatory design; crowd science; civic science; participation

ACM Classification Keywords
Design; Human Factors

INTRODUCTION
A newfound interest in public participation in science – often loosely referred to as citizen science (CS) – is taking root among scientists, governments, and the public [2,15]. Since its introduction two decades ago, however, the scope of the designation CS has expanded significantly, influencing its denotations and connotations. In response to this expansion, a welter of descriptors beyond "citizen" have come to distinguish CS projects — e.g. crowd, street, networked, massively collaborated, stakeholder, democratic, participatory, and civic, to name a few. The variety in the descriptors prompts one to ponder whether the community of CS is of one mind regarding what its main thrust is. To add grist to this mill, the CS community has voiced an entangled set of concerns regarding the limited forms of citizen participation in projects [2,15] — concerns that can be broadly described as the problematics of participation.

CHI'16, May 07 - 12, 2016, San Jose, CA, USA

ACM 978-1-4503-3362-7/16/05..$15.00.
DOI: http://dx.doi.org/10.1145/2858036.2858575

Disentangling the problematics of participation calls for clarifying the overused and underspecified notion of participation itself. To quote Cornwall [6] who grapples with the problem in another context, "So many claims to 'doing participation' are now made that the term is mired in a morass of competing referents." This task will occupy us for the rest of this paper. Borrowing from the critical tradition of Participatory Design (PD), we will unpack participation as it relates to other aspects of CS including work organization, technology, and politics.

The paper will be organized as follows. First, we will draw parallels between the respective histories of CS and PD. These parallels motivate our resorting to PD to shed light on the problematics of participation in CS. We discuss various aspects of participation, first in a comparative case study and then in a more extensive study of CS projects. This data, in turn, will prompt us to conceive of two ideal types of CS projects — i.e. Crowd Science and Civic Science. In general, Crowd Science puts citizens at the service of science while Civic Science is more concerned with initiating a dialog between the concerns of citizens and the goals of research. Confirming previous findings [3], our data also shows a distribution of CS projects between Crowd and Civic that is heavily skewed towards the former. We will close by asking what PD can contribute to this debate.

CITIZEN SCIENCE AND PARTICIPATORY DESIGN: PARALLEL DEVELOPMENTS
Participatory Design, as a broad approach to the design of workplace and living environments, strived to turn users from informants into participants throughout the design process [14]. The demand for user involvement in the design of environments of everyday life was based on an emancipatory commitment that sought to give voice to marginalized groups.

The emancipatory ethics suggests interesting parallels between CS and PD. First, historically, both movements can be understood as a response to the specific circumstances of their time — in PD, the limitations of the first paradigm in HCI [10] to fully engage users in the conceptualization and design of systems; in CS, an increased appreciation of the constraints of the traditional model of science to meet the mounting challenges of modern polities [12]. Second, the development of both CS and PD has a technical orientation. By technical, we mean the ensemble of technologies, tools, and techniques that CS and PD have employed in order to realize their participatory ambitions. The technical dimension

provides perhaps the most concrete aspect of similarity between CS and PD, and one most amenable to intervention by the CHI community, as we will demonstrate below. Finally, insofar as CS and PD were both geared towards engaging citizens, they have faced similar obstacles and challenges in realizing "genuine participation" [14] in their respective domains.

By drawing these parallels between CS and PD, we seek to extract insights from the latter that can inform the problematics of participation in the former. Beyond this, thanks to the relatively long tradition of PD, the CHI community is in a unique position to contribute to the design and implementation of CS projects.

THE PROBLEMATICS OF PARTICIPATION

Central to both CS and PD is the notion of participation. Focus on participation is meant to emphasize that *all* the various stakeholders (citizens, scientists, technicians, designers, developers, policy makers, etc.) should have a voice in the conception and implementation of a scientific or design project. Discussions of participation in the PD literature have revolved around three dimensions: theoretical, practical, and political [13].

Theoretically, PD has been part of a broader shift from mentalistic perspectives of cognition to a situated view that considers human thinking and activity as interplay between agential goals and the emerging contingencies of the immediate environment [17]. This shift implied an understanding of design as an iterative process of reflection-in-action rather than a linear, rational sequence of subtasks [1].

Practically, PD has had to structure participation in a way that puts the above emphasis on reflection-in-action into practice. It has also counseled the use of more transparent technologies with which users can interact better and upon which they can reflect more readily. Both in methods and technology, then, PD has spearheaded a move away from closed and determinate systems to open-ended and ambiguous configurations that invite and encourage, rather than block, ongoing participation and engagement on the part of all stakeholders.

Politically, PD has been explicit in drawing attention to the neglect of the interests of marginalized groups that nevertheless become the major stakeholders once a design is deployed. Advocates of PD fear that, despite the rhetoric surrounding modern technology, it is shaping up to be another instrument in the hands of the few to control the many. The question of politics is at the bottom a question of purpose: is a particular project geared towards control or empowerment?

Implementing the lessons of PD in CS faces serious complications. Through grappling with these complications, however, we can shed light on the problematics of participation in CS. In what follows, we will attempt this in the context of two map-making projects.

CROWDS AND CIVILIANS: THE MAP-MAKING CASE

Modern map-making typically involves first acquiring visual data from satellite imagery and aerial photography technologies, then analyzing and assembling them into maps that highlight certain spatial features of a region. Since the equipment and software required for this process are expensive and sophisticated, map-making has been mostly limited to professional communities of expert cartographers. Recent studies [15], however, have shown that the lay-expert divide in cartography might be exaggerated and, at least in certain areas, the quality of map analysis by citizens "rivals" that of professionals.

This realization forms the impetus behind two map-making projects, i.e. Cropland Capture[1] and Kite Mapping[2], both of which rely on citizen help for map construction. Despite their surface similarities as CS projects and their shared interest in mapmaking, however, these two projects show different theoretical, practical, and political commitments. Theoretically, they have interpreted the diminished lay-expert divide very differently: Cropland Capture sees in this an unprecedented opportunity for recruiting citizens to help scientists remedy their poor understanding of cropland locations across the globe; Kite Mapping, on the other hand, sees an opening for contesting official maps and challenging the interests they serve by providing citizens with DIY map-making capabilities.

Practically, citizens are employed for contrasting tasks. Cropland Capture's mapmaking is a tripartite process. First, scientists identify a land area where satellite images could use improvement. Then, images of these areas are relayed to volunteer citizens who examine them and note, "only with a simple yes or no answer,"[3] whether they can detect croplands or not. Finally, citizen-verified farmland information is passed back on to scientists who use it to advance land research. High score tables and lists of the best contributors are added to the process to make it more game-like. Thus, citizen involvement in Cropland Capture is limited to the single task of identifying croplands in images. Compare this to the organization of activities in Kite Mapping: here, participants pick the place and time they make maps; they are then provided with guidelines and support for buying, assembling, and flying a map-making toolkit, as well as using a tailor-made software called Mapknitter to stitch together their own map of an area; the result is then submitted to the public record and may be used for advocacy and activism as well as research.

Technology use differs in Cropland Capture and Kite Mapping as well. Cropland Capture consists of a gamified

[1] http://www.geo-wiki.org/oldgames/croplandcapture/

[2] http://publiclab.org/wiki/kite-mapping

[3] https://www.youtube.com/watch?t=135&v=C_Jxa_JiEmw

web platform, a smartphone application, and geo-tagged pictures available through applications such as Panoramio or Flickr. Satellite images on the screen are accompanied by rating and classifying capabilities. Kite Mapping, on the other hand, uses open source tools and humbler technologies like household items that are already familiar to many. As such, they lend themselves better to a concrete understanding of aerial photography in Kite Mapping. Moreover, unlike satellite imaging, the low cost of such technologies makes them accessible to a broader socioeconomic base. Kite Mapping's technology support comes in the form of wikis and other online collaboration tools, as well as a community of cartographers who provide in-person assistance throughout the map-making process.

The above differences are accompanied by a corresponding contrast in the end goals and politics of these two projects. Kite Mapping concerns itself with *local* issues of civic and environmental significance. It aspires to provide the means for ordinary citizens to gather information *on demand* and use it for civic purposes. Underlying this aspiration is a recognition that maps have political significance. As the website notes, "maps are often used by those in power to exert influence over territory, or control territorial narratives."[4] A case in point is the BP oil spill of 2010, after which community members in the West Coast came together to challenge official narratives of the scale and impact of the catastrophe.[5] In Kite Mapping, then, giving citizens a voice goes beyond mere rhetoric because citizens with investigative projects can potentially put an aerial mapping system together quickly and easily. Cropland Capture, on the other hand, conceives of citizens as gamers poised to contribute to the advancement of cartography. As a promotional video[6] on the website suggests, the aim is to "help you help science… ." As such, citizens have little control over the source and significance of the data they are asked to analyze, or the ambitious end goals of the project as a whole, i.e. increasing food security and making sure the world grows enough food for everyone, while also reducing poverty and curbing climate change.

CITIZEN SCIENCE: BROAD SPECTRUM, NARROW ENGAGEMENT

Our analysis of the way Kite Mapping and Cropland Capture imagine and implement citizen participation might seem anecdotal and unrepresentative of the diversity of participation patterns in CS in general. In response, we can turn to the several classifications that have tried to capture this diversity [2,8,15]. The most well-known and comprehensive of such classifications offers a typology of projects in order of increasing citizen participation – i.e. Contractual, Contributory, Collaborative, Co-created, and Collegial (see [16] for more detail.) We used this classification in a study of 16 online CS directories including SciStarter, Zooniverse, CitSci, and the Scientific American Citizen Science List. Sampling was guided by three existing typologies ([15,17,18]) and the resulting projects were classified according to the five-tier classification above. The results are displayed in Figure 1 below.

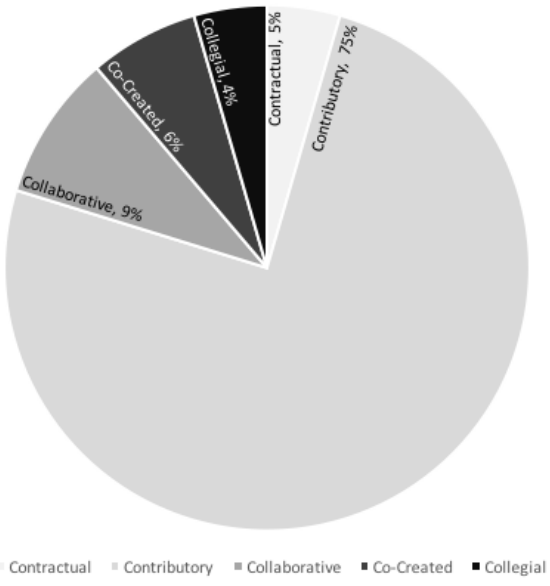

Figure 1. Distribution of 89 projects among five classes of participation

The arrangement of slices in the pie chart is such that darker colors indicate more involved forms of citizen participation. The most important takeaway is that in a majority of the projects (those classified as Contractual or Contributory), participation is restricted to data collection. Put differently, 80% of the projects roughly resemble Cropland Capture above in its limited form of citizen participation. On the other hand, Collegial and Co-created projects (those that enable and encourage citizen participation in most/all stages of knowledge production) comprise a minority of the sampled projects. In other words, 11% show extensive patterns of participation similar to Kite Mapping above. The 9% classified as Collaborative fall somewhere between Kite Mapping and Cropland Capture with respect to participation.

The data clearly shows that Cropland Capture and Kite Mapping can serve as ideal types at the opposing ends of a spectrum of participation. Their contrast, although anecdotal, is symptomatic of a broader division in the CS landscape, which appears to be not so much monochrome as black and white.

On the one hand, there are Crowd Science projects that put citizens at the service of science. While similar in organization to conventional science, these projects resemble other crowdsourcing regimes of knowledge production in the

[4] https://publiclab.org/wiki/raw/16178

[5] https://publiclab.org/wiki/gulf-coast

[6] https://www.youtube.com/watch?v=hzFMVqufG2o

way they tap into the massive pool of citizens with their peculiar interests, low-cost labor, and unique (and uniquely human) capacities. Citizen participation is typically minimal in scope and limited to the more menial tasks such as recording observations (e.g., presence of certain bird species in an area), measuring things (e.g., the existence of pollutants in air or water), monitoring certain conditions (e.g., the level of snowfall in an area), and classifying and annotating data (e.g., recording frog sounds in wetlands). On the other hand, there are Civic Science projects, which conceive of CS as more of a two-way street between scientists and citizens. Resembling Participatory Research in spirit [5], these projects are grounded in an increased reliance on local knowledge and attention to civic concerns. Rather than employing citizenry for rote tasks, Civic Science involves them in the processes of analyzing and using data, interpreting results, producing knowledge, and even negotiating the goals of specific projects.

The Crowd vs. Civic tension is already reflected in the dual roots of the term "citizen science" itself. According to one definition [2, 15] better aligned with what we have termed Crowd Science here, CS was meant to encompass various forms of "scientist-driven public research projects." Yet, according to a second interpretation [3,10] more in line with what we have termed Civic Science, however, CS comprises projects where scientists assist citizens or local knowledge is developed and enacted outside the confines of scientific institutions. This tension raises a host of issues for the CHI community, the most important of which seems to us to be: to what extent can the present, dichotomous state of affairs be ameliorated. Put differently, (how) can Crowd and Civic forms of participation be reconciled?

GENUINE PARTICIPATION THROUGH CRITICAL ENGAGEMENT

The asymmetry between Civic and Crowd Science should be music to the ears of those who have worked in PD for a long time. As far back as 2001, Eevi Beck argued [2], rather persuasively, that "participation is not enough." This warning was meant to ring an alarm to those who sought a viable alternative in PD to the limited notion of "user" commonly accepted in psychologically driven studies of humans and their "needs." This was favorably received by part of the PD community, initiating the launch of projects that strived to ensure rather than assume genuine participation. One such project was Neighborhood Network, which sought to facilitate "critical engagements between people, technology, and the urban environment" [7]. By "critical engagement," these authors meant "experiences that bring about the reflective analysis and interpretation of issues, building from traditions in informal learning and the arts" (ibid). Following this approach, Neighborhood Network managed to involve the public in the conception, design, and implementation of a public project that allowed them to take part in the improvement of their environment. Rather than *using* citizens as environmental sensors and collectors of data, in other words, the project *equipped* them with technology (i.e., sensors) that would allow them to understand and intervene in the process.

CS seems to now face the same quandary. The overwhelming bias toward Crowd Science, we argue, is symptomatic of the same underlying issue that Beck has identified in PD — namely, that participation is not enough. In our attempt to understand this issue, PD provides us with a lens through which we can appreciate how the Crowd vs. Civic dichotomy is predicated upon different understandings of citizen participation. This was clearly manifest in the contrasting patterns of participation in Cropland Capture vs. Kite Mapping as well as the broader distribution of projects examined in our aggregate study. We, therefore, suggest that concepts such as "critical engagement" might provide a useful starting point towards more Civic forms of participation. To demonstrate how, we would like to briefly discuss the problem of motivation, which seems to constitute a critical component in sustaining CS projects.

In one of the first treatments within the CHI community of CS, Eveleigh et al. correctly identifies the problem of rapid turnover of participants in projects, as manifested by the large number of "dabblers" who stop participating after a brief period of engagement [8]. Attributing this state of affairs to a lack of motivation among participants, the authors advise designs like gamification which can entice citizens to more sustained participation. While concurring with their identification of the issue, we suggest that motivation can be more meaningfully, and perhaps successfully, tackled by designing projects that invite genuine participation through critical engagement. In our view, motivation, rather than being a simple driver of action, is itself an outcome of the socio-technical configuration of systems and activities. The case of Kite Mapping detailed above provides a useful model of what this might constitute: open-endedness, collective activity, and humble technologies. By no means does this combination of elements provide a cure-for-all-ills of CS. But it does provide a vivid portrayal of what works.

LOOKING AHEAD

The CS landscape our study paints is one where vast swaths of Crowd Science are dotted with Civic Science projects here and there. Our goals in raising an alarm here have been twofold. First, to attract attention to the ways in which CS remains wedded to the broader socio-economic system, to the interests of a few, and to the traditional modes of thinking about the place of science in society [12]. This is remiss, given the potential of CS, particularly in the form of Civic Science, to enable more transparent, accountable, and democratic modes of knowledge production, learning, and governance. A second goal has been to hint at the possibilities of a productive cross-fertilization between the CHI and CS communities. Barring a few exceptions like [8], this theoretical space remains underexplored. We take this study to be a small step in that direction.

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