Reimagining Meaningful Data Work through Citizen Science

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Data work is often completed by crowdworkers, who are routinely dehumanized, disempowered, and sidelined. We turn to citizen science to reimagine data work, highlighting collaborative relationships between citizen science project managers and volunteers. Though citizen science and traditional crowd work entail similar forms of data work, such as classifying or transcribing large data sets, citizen science relies on volunteer contributions rather than paid data work. We detail the work citizen science project managers did to shape volunteer experiences: aligning science goals, minimizing barriers to participation, engaging communities, communicating with volunteers, providing training and education, rewarding contributions, and reflecting on volunteer work. These management strategies created opportunities for meaningful work by cultivating intrinsic motivation and fostering collaborative work relationships but ultimately limited participation to specific data-related tasks. We recommend management tactics and task design strategies for creating meaningful work for "invisible collar" workers, an understudied class of labor in CSCW.

CCS Concepts: • **Human-centered computing → Empirical studies in collaborative and social computing**.

Additional Key Words and Phrases: citizen science, data work, crowd work, meaningful work

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1 INTRODUCTION

In a growing digital economy, data work has become a commodity synonymous with wage labor and gig work. Human data workers clean, sort, report, label, transcribe, and translate data to train algorithms and fuel large-scale analyses. In traditional paid crowd work, data workers are routinely sidelined, silenced, disempowered, hidden, and minimized [51, 52, 65, 74, 75]. In response to these conditions, there are increasing calls to change relationships between crowdworkers and requesters.

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In their seminal paper, Kittur et al. ask, "Can we foresee a future crowd workplace in which we would want our children to participate?" [43]. Here, we turn to citizen science to explore alternative arrangements for crowd-sourced data work.

Citizen science projects aim to open the scientific process to public participation, often involving members of the public as data workers labeling and transcribing large data sets. While there is a wide range of citizen science arrangements [4, 10, 28, 80, 86], we focus on contributory citizen science projects [10] that engage participants as data workers in similar tasks to those performed by paid crowd workers. Reliant on volunteer labor, contributory citizen science projects do not offer the extrinsic rewards associated with paid crowd work. Despite the absence of extrinsic motivation, these kinds of projects have been incredibly productive [42, 47, 59]. The fact that volunteers perform this data work in their free time and remain engaged for long periods of time without financial incentives indicates that the experience of participating in citizen science is very different from that of participating in paid crowd work. To better understand what makes these data work projects effective outside of the paradigm of paid crowd work, we offer an empirical account of the work that goes into managing contributory citizen science projects.

Contrasting paid crowd work and contributory citizen science as two paradigms of crowd sourced data work, we contribute 1) an account of the work of managing contributory citizen science projects, 2) a discussion of work practices that contribute to meaningful crowd-sourced data work broadly, and 3) recommendations for making paid crowd work more meaningful. We first detail the strategies, goals, and challenges of managing contributory citizen science projects based on our interviews with 13 project managers of citizen science initiatives. While the backgrounds of project managers varied from professional scientists to educators, they were all responsible for the delegation and oversight of data work performed by volunteers. Our interviews document the work that went into creating, launching, and maintaining these projects. Several categories of management tasks emerged, including aligning science goals, minimizing barriers to participation, engaging communities around science topics, communicating with project volunteers, and offering rewards for participation. Navigating these types of work, project managers tapped into intrinsic interests to encourage volunteer participation and fostered positive relationships with participants, creating opportunities for meaningful work. We discuss how these work practices indicate a starting place for understanding meaningful work in the context of crowd sourced data work. Finally, translating the work and strategies of citizen science project managers, we provide several recommendations to make crowd-sourced data work more meaningful. To be clear, we do not argue that crowdworking tasks should become citizen science tasks. Rather, our intention is to highlight strategies that contribute to more meaningful data work in citizen science that could be applied to crowdworking tasks as they currently exist. Acknowledging the fundamental differences between paid crowd work and contributory citizen science, we end by providing recommendations for managing crowd work and designing tasks that promote meaningful data work. We hope these recommendations will inform meaningful work across contexts of crowd-sourced data work.

2 RELATED WORK

We know that job design and organizational culture shape meaning in the workplace, but less is understood about what it looks like to design meaningful work for crowd workers — a newly emerging class of data workers whose conditions do not reflect those of white-collar workers often at the center of research in CSCW and HCI. To begin to understand how to create more meaningful work for these "invisible collar" workers [18], we turn to citizen science as an example of labor that is mediated through similar conditions of online data work. Thus far, citizen science work in HCI has focused primarily on increasing volunteer engagement through platform design. Less attention has been given to understanding relationships between project managers and volunteers,

a critical component of the work space. By comparing citizen science to paid crowd work, we can begin to reimagine tasks, platforms, incentives, and arrangements of crowd work that result in more meaningful jobs.

2.1 Background on Citizen Science

The term *citizen science* refers to projects that engage non-professional members of the public in the scientific process. Well-known citizen science initiatives and platforms like eBird [1], iNaturalist [2], Foldit [3], Zooniverse [4], and SciStarter [5] have facilitated productive collaborations between professional scientists and members of the general public. HCI researchers have contributed much to the design of these platforms, including increasing engagement through gamification [12, 26, 39, 49, 60, 79, 82], increasing effectiveness of volunteer training [53], fostering community [62], maximizing contributions from short-term volunteers [26], and increasing contribution quality [62].

A core component of citizen science is understanding the motivation that drives both parties — volunteers and project managers or professional scientists — to take on the work. For volunteers, intrinsic motivation, including personal interest in the project topic, desire to contribute to science, community participation, and recreation are the primary factors of participation in citizen science [4, 21, 22, 38, 82]. Volunteer motivations change over time [68], and motivational factors influence contribution behavior [26]. There has been less work examining the motivations of professional scientists who lead citizen science projects. Rotman et al. found that scientists primarily viewed citizen science as a tool for large-scale data work that could be used in peer-reviewed publications. The altruistic goal of contributing to the greater good by educating the general public was a secondary goal for scientists interviewed in Rotman's study, as was belief in the principle that science should benefit the greater good [69]. While studies examining the motivational factors of citizen science managers are limited, the benefits of engaging volunteers in citizen science are widely acknowledged. In 2009, Silvertown announced "a new dawn for citizen science," arguing that three factors were contributing to an explosion of citizen science projects: (1) the increasing ability for technology to facilitate large-scale distributed projects, (2) recognition amongst professional scientists that the public can contribute labor, expertise, and computational power, and (3) new requirements from science funders and institutions pushing scientists to participate in outreach related to their project [78].

As initiatives for public participation in science proliferate, there is a growing diversity of arrangements that constitute citizen science [4, 28, 80, 86]. Bonney et al. characterize models of public participation in scientific research in three major categories: *contributory projects*, in which members of the public contribute data to projects designed by scientists, *collaborative projects* in which members of the public might influence project design, analyze data, or communicate findings, and *co-created projects*, which involves members throughout the full scientific process [10]. Importantly, this typology emphasizes the level and forms of participation as a key distinguishing factor among different forms of citizen science.

As the characteristics of these projects and the roles of those involved vary widely, there is also debate over what terms best describe this practice (e.g., participatory science, community science, civic science). The term *crowd science* has more recently emerged to describe projects in which professional scientists enlist crowds to contribute to research. So far, publications around crowd

[1] ebird.org
[2] inaturalist.org
[3] fold.it
[4] zooniverse.org
[5] scistarter.org

science are primarily engaged in conversations on crowdsourcing and most closely align with a "productivity view" rather than a "democratization view" of citizen science [76]. Franzoni et al. identify a large overlap between crowd science and citizen science and argue that the terms actually "reflect different disciplinary lenses," which are used to focus analysis on different features, mechanisms, and outcomes [28]. Eitzel et al. contribute a rich discussion of the many complexities in choosing terms used to discuss citizen science, pointing out that debates over what to call citizen science reveal tensions in what citizen science is. [25]. Recognizing that these terms remain contested and do not necessarily capture the nuances of the individual projects included in our study, we choose to use "citizen science" as the most widely recognizable term for scientific work involving members of the public, and we use "volunteers" to highlight the unpaid work contributed by people engaged in these projects and differentiate this work from paid crowd work.

In this project, we look specifically at contributory crowd science projects, where volunteers participate in data work tasks that involve basic data collection, image processing, or transcription. Acknowledging that these projects more closely align with crowd work than collaborative or co-created citizen science projects, this study seeks to uncover the specific practices project managers use in citizen science that differ from traditional, paid crowd work, in order to identify opportunities for facilitating meaningful data work.

2.2 Crowdscientists vs crowdworkers

Similar to citizen science, crowd work tasks can include completing surveys, labeling images, or transcription. However, there is an obvious difference between the two genres of data collection tasks — while citizen science relies on the goodwill of participants, many crowdworkers are often using platform labor as a main (or even primary) income source [37]. As a result, tasks designed for crowdworkers generally prioritize the needs of the requesters who post them online. Amazon Mechanical Turk, Prolific, Clickworker, and UpWork are just a few examples of the types of online crowd work platforms that facilitate the exchange of data work for money. The difference in compensation is reflected in the broader paradigms of data work; where citizen science tasks are structured to accommodate participants' involvement, the experience of crowdworkers is rarely taken into account when requesters design crowdworking tasks.

Crowd work requesters' approach to data work has been the subject of concern in recent years. In general, crowdworkers are placed "behind the screen" [65], with their presence reduced to "human intelligence" [1] capable of powering larger AI and ML systems. Sambasivan et al. observe this as a larger pattern in which the model work is desirable, socially-respected work, and the actual data labor required to power those systems is minimized in importance [74]. Further, Sambasivan & Veeraraghavan describe the way workers performing that labor are both silenced and disempowered in the larger data production process [75]. Crowdworkers are routinely sidelined once their work has been submitted, and they are not seen as a part of the larger systems produced, nor are they given a voice in how those systems should be designed, despite the fact that their labor is necessary for system development [51, 52].

There have been calls to change the crowdworker-requester relationship, given the triangular relationship of stakeholders (workers, requesters, and platforms) in the larger digital task ecosystem. Among those, the Turkopticon project calls attention to the way Amazon Mechanical Turk (AMT) sidelines Turker (AMT workers) concerns [40]. The Dynamo project [73] aimed to help workers on platforms like AMT better collectivize their frustrations and push for platform-facilitated change. Rothschild et al. described how tasks on platforms like AMT could be made more respectful of workers [67]. These calls are increasingly important in the face of the ever-growing push for data to train generative AI systems and services. For example, OpenAI's ChatGPT system was refined by Kenyan content moderators, who have since spoken out about their treatment at the hands

of OpenAI and subcontractor Sama, describing the impacts of traumatizing work on the rest of their lives [71]. Requester approaches to eliciting data work from distributed crowd work harm and traumatize their workers at worst, and offer few opportunities for meaningful work at best. Our work seeks to reimagine the kinds of work that crowd workers do by understanding the strategies used in citizen science to engage and maintain data workers without pay. Placing citizen science in contrast to paid crowd work, we use the lens of *meaningfulness* to understand the practices that citizen science project managers undertake to create and sustain volunteer participation.

2.3 Making Meaningful Work

Citizen science literature in HCI often focuses on increasing volunteer engagement through gamification [12, 26, 39, 49, 60, 79, 82], but engagement is only one element of what makes work meaningful [29]. According to new ideas emerging from studies of employee satisfaction, engagement alone is not representative of a positive experience; rather, we need to look at how employees are being empowered and energized to do meaningful work [44]. Recent calls urge researchers to consider the employee as a whole in order to design workplace automation that considers both the pragmatic and emotional characteristics that shape meaning and our professional identities [70, 77].

Drawing from organizational studies, there is a whole category of research that points out the ways that job design, managerial decisions, and organizational culture can add and remove meaning from work [5, 48, 89]. We adopt the definition proposed by Bailey and Madden: meaning is when an individual perceives an authentic connection between their work and a broader transcendent life purpose beyond the self [7]. The premise of meaningful work is to encourage and support workers to create jobs and tasks that positively impact and add value for each employee. Increasing meaningfulness at work has positive impacts for both individuals and organizations, resulting in greater productivity, lower employee turnover, and higher job satisfaction [2, 8, 64]. However, meaningfulness is complex in that it is created and sustained based on an individual's values and environment [48]. We know that engagement, purpose, and contribution are several key components that make work meaningful. According to DeBoeck, factors that also shape meaning include perceptions of untapped potential related to skill variety, autonomy, and job feedback [19]. The plurality of meaning has made it a contested area of research in management studies, but the resounding sentiment is that meaningful work is desirable for both organizations and employees and is a fundamental human need [88].

While the definition of meaningfulness remains debated, we can turn to the inverse to better understand the implications of meaning on workplace practices. Bailey and Madden examined white-collar environments and found that leadership decisions can directly remove meaning from work [6]. They identified seven key actions that affect meaningful work, including disconnecting people from their values, taking employees for granted, giving people pointless work to do, treating people unfairly, overriding people's better judgment, disconnecting people from supportive relationships, and putting people at risk of physical or emotional harm [6]. These characteristics of meaning are tied to traditional office settings that rely on continuous working relationships. Leaving the white-collar office space, the authors go on to study a variety of jobs, including garbage collectors, stone masons, and academics. In these cases, Bailey and Madden attribute meaningless work to a lack of understanding of the larger contribution with no end in sight, a lack of control over the use of time, and tensions between work and personal time [7] While meaningful work is clearly important to cultivate positive experiences for workers across settings, we have not yet explored what it means to create opportunities for meaningful work in non-traditional job domains like crowd work.

Existing research recognizes that classes of workers assign different meanings to tasks. By examining work across pink-, white-, and blue-collar professionals, Lips-Wiersma et al. highlight that meaning can be traced to professional identities rather than solely individualist values [48]. In addition, Saari et al. illustrate that meaning is tied to autonomy, competence, relatedness, and beneficence [72]. However, these values are interpreted differently from traditional white-collar workers and are influenced by leadership and technology use [72, 77].

Crowd work represents another class of worker recognized as "invisible collar labor" [18]. Crowdworkers are already at a disadvantage because they are hidden from view and often never meet the project requesters, yet remain subject to leadership (as an employer for a given task). Virtual platform work is predicated on anonymity and isolation. The role of task requesters in determining the experience of individuals performing those tasks is increasingly a subject of attention (e.g., [67]). However, unlike more traditional forms of labor, crowdworkers may work for a given requester for a minute or less. This makes it difficult to enforce basic workplace protections, let alone more enjoyable or meaningful experiences of work, without changing managerial practices surrounding data-work.

Ideas about what makes work meaningful differ across work contexts, but little is known about how to make crowd work, or invisible collar labor, meaningful. Crowd work is the backbone of an increasingly digital economy, but it is failing to provide positive work conditions, leading to calls to change relationships between workers and requesters. In citizen science, we see an alternative approach to data work that relies on intrinsically motivated volunteer labor. In contributory citizen science projects, which most closely resemble traditional crowd work, we see an opportunity to reimagine crowd labor as meaningful work by unpacking the approaches of citizen science project managers.

3 METHODS

We took a qualitative approach to understand the work that citizen science project managers did to facilitate citizen science data work. We interviewed 13 participants between March and December 2023. Participants were identified via online citizen science platforms, Zooniverse and SciStarter, or through online listings of active citizen science projects, and participants were recruited via email based on their publicly available contact information. All participants worked as project managers for citizen science projects that engaged volunteers in collecting or cleaning scientific data. Some participants were full-time citizen science project managers, and others managed citizen science projects among other work responsibilities. For everyone we spoke with, managing these projects required significant time and resources. There was a range of experience levels amongst our participants: the newest project manager we spoke to managed a project that launched only a few weeks earlier, but over half of our participants had spent years running their current projects. About half of the participants had experience managing multiple citizen science projects, while the others had experience with one project only. Participants were selected through purposive sampling in order to obtain data that represented a range of disciplines, including astronomy, environmental science, geology, history, etc., and a variety of institutions, including public and academic institutions. Because our study focuses on the work of citizen science project managers, we did not interview volunteers. Our study is therefore limited to the perception of project managers. For an overview of our participants, please see Table 1.

Interviews were conducted in a semi-structured style. Questions covered the daily work of launching, managing, and maintaining citizen science projects, and asked participants to reflect on their successes and challenges, their relationships with their volunteers, and their rationale for engaging with citizen science. Twelve participants completed interviews over digital video conferencing software, with one to two authors present at every interview. P7, P10, and P11 were

Table 1. Overview of the backgrounds and task types of participants in our study.

Participant Number	Field	Task Type
P1	Environmental Science	Data collection/counting
P2	Environmental Science	Data collection/sampling
P3	Space Science	Image labeling/classification
P4	Environmental Science	Data collection/sampling
P5	Social Sciences	Transcription
P6	Social Sciences/Natural Sciences	Transcription
P7	Environmental Science	Data collection/sampling
P8	Biology	Image labeling/classification
P9	Environmental Science	Transcription
P10	Space Science	Image labeling/classification
P11	Space Science	Image labeling/classification
P12	Biology	Data collection/sampling
P13	Biology	Image labeling/classification

interviewed by a pair of two authors, and one author interviewed the remaining participants. One participant, P12, completed the interview in the form of an open-ended questionnaire via email. Interviews lasted between 21 and 60 minutes, and a total of 6 hours and 50 minutes of audio recordings were transcribed and analyzed.

Interview data was analyzed based on the framework of open coding [35] and thematic analysis [14]. The first author completed an initial close read of all transcripts to identify emerging themes and propose an initial codebook. This preliminary codebook covered six themes: responding to participants, protecting participant safety, educating participants, respecting participant expertise, motivating efforts, and minimizing barriers, each with subcodes cataloging the daily work practices and strategies of project managers. Next, three authors each coded three to four transcripts with the initial codebook and met weekly to discuss emerging themes, adding three additional themes: providing feedback, acknowledgment and rewards, and broader impacts. After all the transcripts had been coded, the full group met to revise and reorganize the codebook, resulting in seven refined themes: aligning science goals, minimizing barriers, engaging communities, training and education, communicating with volunteers, rewards, and perceptions of volunteers. Three authors then re-coded all the interviews using the updated codebook. Thematic groupings continued to be refined throughout the writing process, as we collaboratively identified exemplary quotes and articulated relationships between themes in writing [14].

4 FINDINGS

Our interviews revealed a robust concern expressed by citizen science project managers for volunteers. This concern contradicts the prevailing paradigm in crowd work, in which requesters are primarily concerned with extracting high-quality task submissions rather than the experiences of the people who create those submissions. In the rest of this section, we detail specific strategies project managers used to shape volunteer experiences; here, we highlight that this prioritization of volunteer experiences takes place throughout the entire citizen science project life cycle. From the initial design stages of the project, project managers are concerned with issues such as *aligning science goals* with participatory outcomes and *minimizing barriers to participation*. Throughout

the execution of the project, they are actively building relationships with volunteers by *engaging communities, communicating with volunteers*, *providing training and education*, and *rewarding contributions*. Finally, when reflecting on their experiences with citizen science, project managers' *perception of volunteers* was characterized by respect and appreciation for their knowledge and efforts. This overarching pattern suggests that cultivating a healthy partnership between volunteers and project managers in data work is an ongoing, open-ended process that goes beyond pre-execution design considerations.

4.1 Aligning Science Goals

While paid crowd work projects are typically focused on obtaining completed work quickly and cheaply [3, 43], our interviews indicated that citizen science project managers simultaneously pursued high quality data work and positive volunteer experiences by aligning productivity and participatory goals in early stages of their projects. Productivity goals reported by interviewees centered around contributing to knowledge in their scientific domain or improving tools used for data analysis (P7). Participatory goals, meanwhile, centered around engaging the public in the scientific process, for example, by improving scientific literacy (P3, P8), or bringing specific benefits to volunteers (P11). When project managers successfully aligned scientific and participatory goals, citizen science proved to be a highly successful method for pursuing both goals simultaneously.

From the very beginning of project conceptualization, project managers reoriented their productivity goals around the norms of citizen science. Participants frequently admitted that citizen science was not the most efficient way to complete data work. P3 explained that in order to become a citizen science project manager, as a scientist, "*you have to already believe that it [engaging the public] has value and see it as something that is valuable*." Critically, P3 continued, this must be the case because using volunteers to complete data work may not be "*actually saving you time or effort.*" In other words, launching a citizen science project was not viewed as an easy or quick way to get free data work, because even though participants were not paid, citizen science projects nonetheless required significant time and resources.

One way interviewees aligned productivity and participatory goals was by identifying topics that could align their goals with public interest. Some project managers chose to shift their scientific goals to better channel volunteer interest. For example, one project originally aimed to digitize military records across a multitude of WWI soldiers. However, P5 decided to shift the organization of the project to focus on transcribing documents that traced the lives of individual soldiers because it was easier to engage volunteers with the narrative of individual soldiers' lives. This change increased volunteer participation, which ultimately resulted in higher productivity as well.

Other project managers adopted participatory goals to access the large participant pool necessary to perform some scientific projects. For example, P10 had initially crafted scientific goals that required large amounts of human data processing. After they received interest from a small group of citizen scientists connected to a co-worker, P10 saw the opportunity to engage a wider range of volunteers in completing the data labeling task. P10 ultimately adopted participatory goals and received funding from a NASA grant designed to fund citizen science projects. In this case, adopting participatory goals provided access to a pool of volunteer labor, a new source of funding, and a new publication venue. Not only did P10 gain immediate project progress from adapting their project to have participatory goals, but they also received longer-term professional benefits as a result of their successful shift to citizen science methods.

A final example of the reconciliation of productivity and participatory goals can be seen in the careful topic or site location of citizen science projects. One interviewee, P7, chose a particular major watershed as a study site, given that there were already activist and community groups actively engaging with the site. P7 wanted to source human verification for automated methods

of waterway pollution detection, and by engaging with the strong community base that already existed for this watershed, they were able to tap into the existing volunteer population.

In short: Each of these examples reveals work that was done to align scientific goals with participatory goals. Some project managers adopted additional participatory goals, others shifted scientific goals to better align with participatory goals, and yet others chose topics or research sites that were conducive to both the scientific and participatory project goals. By aligning these goals, project managers adopted the values of citizen science and were consequently awarded significant benefits, including access to volunteer labor, additional sources of funding, participation in a scientific community, and additional publication opportunities.

4.2 Minimizing Barriers to Participation

Beyond adopting participatory goals, project managers also took explicit steps to make sure their projects were accessible to a wide range of volunteers. In paid crowd work, the burden of overcoming technical barriers or accessibility challenges often falls on the crowdworker [51]. In contrast, citizen science project managers worked to minimize barriers that could limit project participation. These efforts can be grouped into responses to two major concerns: logistical and structural.

Logistical barriers related to issues that volunteers had with completing tasks. Project managers frequently discussed taking steps to reduce these logistical barriers, for example, by diligently making sure their workflows were error-free and intuitive to navigate. Beyond making the process more enjoyable for participants, these steps were also of benefit to the project managers; as P12 explained, "*[s]impler and more straightforward tasks tend to yield better results.*" P12's project involved processing acoustic data, which required great effort from volunteers. P12's team took great care to make the workflow for volunteers as simple as possible, so volunteers could focus on the content of the task itself. Other project managers encouraged broader participation by making it easier to engage and complete a task. For example, several project managers (P6, P8, and P10) reduced the amount of data work that they asked volunteers to complete in a single submission. For P6, this made sense in light of participant experience, as "*There's not a lot of impetus or motivation to keep going if you're working for hours and not even making a dent.*" Other project managers (P1, P3, P7, and P9) discussed how allowing volunteers to contribute digitally, e.g., with a mobile app, was important for increasing engagement. For example, in P7's project, volunteers were able to collect water samples and analyze them directly using smartphones instead of physically sending them to the project team. P7 reflected on their methods, saying that "*when it comes to data collection, really it has to be simple... cheap, easy, very low entry.*"

Structural barriers were external to the task itself, relating to the volunteer's individual context and preventing potential volunteers from taking part in a project. In many cases, project managers circumvented these barriers by making the pathways for engagement more flexible for volunteers. P6 designed their project so that volunteers did not have to commit to any specific amount of time, noting that their digital volunteers could work anywhere from "*five minutes to eight hours a day.*" P6 additionally hosted online office hours and made themselves available to volunteers via email. For P6, this extensive availability was important since it allowed the project management team to "*meet [volunteers] where [they] are.*" Interestingly, P6 also noted that flexible engagement meant accepting that some volunteers simply did not want to engage. For example, some volunteers frequently completed data tasks but did not want to engage with the community forum. Similarly, P7 emphasized the importance of allowing for flexibility in terms of the different levels of volunteer contributions, adding that *"you don't want to pigeonhole yourself"* into only accepting a specific kind of data collection, given that volunteers have different preferences.

Project managers also sought to alleviate barriers that related to volunteers' personal backgrounds or circumstances. P6 and P9 both mentioned that they had heard from volunteers who had challenges

in terms of physical ability or social anxiety. It was important to P9 that these volunteers still wanted to *"engage with the world and still want to feel like they're contributing,"* despite difficulty doing so in-person, making virtual participation options attractive. P6's project involved transcribing excerpts touching on sensitive topics, including racism and suicide, so they employed content warnings so individual volunteers could act accordingly. Similarly, P4 altered their task to require less information from volunteers, which would better accommodate older volunteers who had less familiarity with the relevant technology. For P4, who worked with a marginalized activist group, reducing barriers and making the project equitable was key to enabling their community partners to get "*the information about their water quality that they need*."

Finally, a small number of project managers took steps to reduce material costs of participation, which were more relevant for citizen science projects that involved the collection of physical samples. P2 and P4 recognized that cost was a factor to consider when thinking about how to enable volunteers to contribute. P4 explained how, although the kits were "actually quite expensive," their project team had money allocated from their grant funding to send out water testing kits to volunteers and, in some cases, offer stipends to some of their community partners.

In short: With awareness that barriers deter volunteer contributions, project managers worked to make it as easy as possible for volunteers to contribute to scientific data work. In doing so, our participants displayed an accommodating approach that was sensitive to the variety of barriers volunteers may face. Whereas paid crowd work often puts the burden on the worker, here we see project managers working to reduce barriers to the greatest extent possible.

4.3 Engaging Communities

Paid crowd work does not have a typical paradigm of community engagement, since there is usually no emphasis on community [34]; instead, crowd workers create community on external platforms, such as Reddit forums[6]. In contrast, our interviewees took proactive steps to connect with community groups and individual volunteers. Finding such a community or volunteer pool is, as P5 reported, critical to project success: "*you really need to find a volunteer community that's sort of interested inherently in your topic.*" One key recruitment technology was citizen science platforms, such as SciStarter, Zooniverse, and We Dig Bio, which publicize projects to potential volunteers. Other project managers tapped into local community networks. P4's project team partnered with faith-based communities, utility companies, and other community groups to reach individuals who were at higher risk of household lead contamination. P7 connected directly with existing volunteer groups working to protect a local watershed, which enabled them to tap into a volunteer pool with "*a little bit more... buy-in or know-how.*" P8 reached out to students and teachers, offering to support classrooms interested in incorporating their citizen science project into the broader classroom science curricula. Serendipity also played a role in connecting with volunteer pools — P1 unintentionally connected with existing community networks when volunteers recruited others in their communities to participate, contacting dive shops and divers on their own out of a desire to make sure their community was represented in the study.

Public communication was an important element of engaging communities. When we spoke, P1 was planning the launch of a social media campaign around their new project, having had great success with a similar campaign for a previous project that resulted in legal conservation status for manta rays. P2's project also had specific political goals around reducing nitrate pollution. Regarding the messaging around their project, P2 described efforts to carefully engage with local communities, some members of which might not be natural allies to their political goals. In both

[6]E.g., TurkerNation (https://www.reddit.com/r/TurkerNation/)

cases, these broader impacts rested on community engagement work along with the data that was being collected by volunteer citizen scientists.

Engaging with communities was not always seamless. Interviewees reported multiple challenges. First, because these projects often sought broad participation, it was difficult to speak to, motivate, and engage different audiences at the same time. As P9 pointed out, a single message was not sufficient to motivate a diverse group of participants, as "*what's going to motivate a retired elderly person is different than what's going to motivate a twelve year-old.*" Capacity was another issue that limited the amount of community engagement work project managers were able to engage in (P6). Institutions that project managers worked within played a complex role, sometimes supporting community engagement efforts and sometimes presenting additional barriers. P8's institution, a museum, facilitated community engagement by constructing glass walls that made the lab visible to museum visitors and encouraged P8 to spend time talking with museum visitors. On the other hand, P10 explained that their institution required paperwork and a lengthy approval process before they were permitted to post informational webinars to the Internet, which hampered P10's outreach work.

In short: For projects with specific broader impacts in mind, community engagement goes beyond recruiting new participants — it requires careful engagement of a wide variety of stakeholders to move towards social impact. Once these communities are identified and contact is established, the program managers go to lengths to make sure the partnership benefits community partners. Doing so required consistent attention to community partners over the course of the project.

4.4 Communicating with Volunteers

Communicating with project volunteers constituted a large portion of day-to-day project management work. Whereas crowdworking platforms and requesters have frequently been criticized for lack of communication and unresponsiveness [40], our interviewees indicated a wide range of methods they used to maintain communication with volunteers. Project managers answered questions, hosted webinars, reviewed submissions, responded to participant discoveries, requested feedback from volunteers, and shared project updates. This critical work kept project managers in the loop with participant experience and supported volunteers in feeling a sense of community.

Project managers reported communicating with volunteers through public forums within their project site, direct messages, emails, and webinars, with several interviewees saying they did so on a daily basis. Participating in conversations by answering questions from volunteers, which might include questions about tasks or about the project topic, was an important part of managing citizen science projects. The importance of this work, per P9, comes from the fact that volunteers "*feel heard.*" Additionally, P9 continued, "*it helps to build people a return mechanism to your project, where people really feel like they are contributing something.*" For P9, having volunteers feel that they genuinely were being heard and included in the larger research mission helped the project become successful. Public talk boards, as a key feature of Zooniverse project pages, were used by many participants to facilitate conversations between the research team and project volunteers. These talk boards had the added benefit of creating spaces where volunteers were able to communicate with each other and answer each other's questions (P9). The message board was, for volunteers, "*their own little ecosystem within the project*," P3 observed. Finally, half of our interviewees reported sharing updates on the status of the project with volunteers as newsletters, blog posts, social media, webinars, or website content.

In addition to providing updates and answering questions, project managers responded to feedback from participants. P10 shared how volunteers used the talk board to draw the project manager's attention to corrupted data files, while P3 recalled that volunteers had caught an error in displaying datasets out of order. Project managers also asked questions of their volunteers,

particularly small groups of long-term volunteers, requesting feedback on tasks and training materials (P6, P10, P8). Some project managers (P3, P10) piloted beta versions of their projects with volunteers to ascertain their experience before fully launching. Sometimes this feedback was more than project managers felt they could address — for example, P11 recalled receiving a list of about 30 ideas for potential improvements from a volunteer, but could not implement them because "*each one...is a week's worth of work.*"

Project managers also communicated with volunteers about submitted work. Some volunteers explicitly requested their work to be reviewed (P8). However, manual review by project managers was not feasible at scale. Faced with this problem, some interviewees utilized computation methods to identify outliers, created training materials for people to test themselves (P8), or implemented mechanisms in which the crowd performed review work (P6). Two project managers (P1, P2) described following up directly with volunteers who supplied outlier data. One interviewee (P3) pointed out that feedback couldn't be given to their project volunteers because there were no "*right*" answers in the classifications. As a result, P3 worked on training their participants to submit their gut reactions without worrying about whether their submission was correct. Similarly, P13 reported that their project team was careful not to over-train participants because part of the motivation for using citizen science is getting diverse respondents so as to avoid expert bias in identifying features in medical imagery (P13). Notably, these communications were treated as opportunities to check in or educate, rather than deter or punish low quality work.

The open, reciprocal communication in these spaces created opportunities to share knowledge that didn't necessarily match the requested data work. Project managers welcomed these insights and made efforts to incorporate and share discoveries back to the volunteer community; in fact, these were moments of celebration. P9 recalled that volunteers called attention to a historical figure who contributed to the texts they were asked to transcribe; Students working with the project manager went on to write reports and create video content sharing information about this historical figure's life. In another transcription project, volunteers made connections across different texts and connections to their personal lives, such as finding ancestors mentioned in historical documents. P6 reflected on these moments, "*It's really exciting to get that knowledge...they're [volunteers] going above and beyond.*" These moments also supported the projects themselves; P8 asked participants to identify white blood cell types in samples, but volunteers additionally identified parasites and lead poisoning, which the researchers hadn't initially considered looking for within the scope of the project. While the project's next stage would make use of AI and ML methods instead of crowd-sourced data work, the insights were so helpful that P8 and their team wanted to keep the project running on Zooniverse, since the additional insight gained were things that "*we just can't train AI for when we don't know what we're asking for.*" In each of these cases, open, reciprocal communication offered opportunities to gain from diverse perspectives, ultimately enriching these projects.

In short: Communicating with volunteers was a significant part of the everyday work of managing a citizen science project. Interviewees utilized a wide variety of channels to communicate with volunteers, including message boards, direct messages, announcements, webinars, and newsletters. Though the two-way communication reported by project managers constitutes a significant use of resources, it created opportunities to train volunteers, celebrate discoveries, and sustain interest in the project.

4.5 Training & Education

In platform-based crowd work, there is typically little inter-task training available. Task-specific training, is usually not transferable between tasks for a given requester. In contrast, project managers in citizen science initiatives not only trained their volunteers to complete tasks, they also strove

to educate volunteers about science methods and topics. Project managers utilized a wide variety of training and educational materials, including training modules (P8), videos (P7, P4), practice problems (P8), written instructions (P4), postcards (P4), handouts (P4), fact sheets (P2), blog posts (P2), FAQs (P2), field guides (P1, P8, P2), and in-person training sessions (P7, P5, P4). Training needs varied by project and by volunteer; one interviewee reported that their project had intentionally chosen not to include required pre-training in order to minimize barriers to potential volunteers (P6). Another project guided volunteers through a training module, then threw out the first 30 classifications made by each volunteer, which were considered to be low quality as the volunteer practiced the task. Some project managers (P1, P4) involved others in training, particularly educators who partnered with the project, sometimes incorporating the tasks into broader curricula, for example, by conducting teacher training workshops to help teachers integrate the project into their curriculum (P8).

Project managers were dedicated to creating accessible educational methods, despite ongoing challenges around communicating complex technical topics. for P11, running a citizen science project was an opportunity for project managers to "*learn something about involving non-experts in complicated work"* that could then be applied in other settings. Interviewees shared a variety of strategies they used to communicate their topics to the general public. P3 strategically used images and similes to make science concepts more intuitive and affirm volunteers "*make people realize , like, oh, I can understand this!*" Similarly, P6 tailored their materials, including project descriptions, summaries, and instructions, as if the volunteer encountering them had never done transcription before. Other participants tried to demonstrate the relationship between the task and a wide variety of topics, such as providing background and pointers to more general information about Mars in order to spark the interest of astronomically-inclined potential volunteers (P10). P2 hoped to educate volunteers more broadly about nitrate pollution without alienating volunteers across the political spectrum. This required, per P2, "*acknowledging nuance and inviting conversation rather than shutting it down.*"

Some interviewees questioned the efficacy of training and education. In fact, training and education may have little impact on actual task performance. P12 reported that including practice opportunities and a quiz on their project website had not enhanced overall submission accuracy. P11 noted that while they hoped training materials would positively impact volunteers, those impacts were hard to document in task performance. Instead, P11 speculated that the training materials had increased volunteers' scientific literacy, and they were certain that volunteers had gotten better at spotting glitches in task prompts, but questioned whether or not that skill would serve volunteers outside of the project setting.

Despite these concerns, most participants saw education as a benefit for volunteers, a key driver of long-term participation, and an important project outcome in itself. The educational rewards of participating in citizen science were seen as a way to give back to volunteers, especially when volunteers were students with relevant career goals (P8). Other project managers believed that educational outcomes were a key factor in long-term volunteer participation, noting that the high return rates of volunteers may be explained, in part, because volunteers feel like they're learning (P9). P6 also saw their project, run under the auspices of a larger public historical institution, as a way to personalize that institution for volunteers. P6 believed the project could help volunteers learn more about archives, libraries, and museum collections. As a result, it was important to include information about the institution, so that "*every project can be a jumping off point to additional knowledge*" (P6).

In short: The strategies shared by interviewees for preparing educational materials highlight how project managers see this work as an opportunity to engage members of the public in science, not just to train volunteers to contribute high-quality data. In fact, much of the work around training

and education actually contributed to project goals beyond producing high-quality submissions. The broad range of benefits shared by our participants highlighted the many ways that *educating* participants, not just training them, strengthened citizen science projects by attracting and retaining volunteers and helping project managers move towards the broader impact goals of their projects.

4.6 Rewards

Unlike paid crowd work, which comes with monetary rewards, citizen science data work was completed by volunteers. Though no pay was involved, project managers recognized the importance of ensuring that volunteers benefited from contributing to their citizen science projects. Rewards for volunteer participation in citizen science varied greatly from those utilized in paid crowd work. However, project managers explained how they designed their projects to offer rewards to their volunteers, including both *intrinsic rewards*, which offered informational, cultural, or psychological benefit to the volunteer simply through the process of contributing, or *extrinsic rewards*, which were expressly granted to volunteers by the project team in recognition of their contributions.

Intrinsic rewards were benefits to the volunteers that project managers saw as natural outcomes of contributing to the citizen science project. These benefits were often informational, in that volunteers got back some of the analyzed data that they contributed to. For example, P4 mentioned how volunteers immediately received information about the quality of their water. In P8's project, volunteers got information on their genotype and microbes growing on their body. Some intrinsic rewards were more subtle and linked to longer-term participation. P5 described how volunteers often tried to find cultural connections in their transcription work and were gratified when those connections emerged. On the other hand, some rewards were more immediate and psychological in nature. P11 spoke about how some volunteers found it relaxing to look at the images in their project and speculated that pleasing images might play a role in volunteer engagement.

Extrinsic rewards took the form of expressions of gratitude, accolades, or material rewards given to volunteers after their contributions to citizen science projects. At the most basic level, project managers reached out to volunteers to thank them for their contributions. P6 described how her project team reached out to the top 10 contributors to individually thank them after everything was completed. These participants were also offered material "swag" as a token of thanks. However, some of the volunteers were uninterested in the material reward, with P6 describing their reaction as, "*no, leave me alone.*" One interviewee described how their team included highly active volunteers as authors on academic publications in order to acknowledge their contributions (P11).

While they spoke of many benefits related to project participation, many of our interviewees saw monetary compensation as unsuitable for the context of citizen science. From a practical perspective, project managers described how they did not typically have the budget to pay volunteers (P4, P8, P11). However, monetary compensation was also seen as being fundamentally incompatible with the goals of citizen science. P11 described how, when offering a monetary incentive to volunteers, "*you have to worry about the data quality in a much different way,*" as data workers might just be interested in the extrinsic incentive and would not feel the intrinsic motivation of "*trying to get it right.*"

In short: Project managers expended significant effort in ensuring that volunteers would benefit somehow through the course of participation and would be recognized for their contributions. Without pay as a motivator, project managers imagined new ways to benefit and recognize their volunteers. Though these efforts were sometimes refused, doing this work created opportunities to motivate volunteers and revealed the attitude of project managers toward volunteers.

4.7 Perception of Volunteers

The relationship between crowd workers and requesters is typically fraught, with neither party fully trusting the other [40, 84]. In contrast, our interviewees described relationships with volunteers characterized by trust, respect, and gratitude. In reflecting on their work, project managers expressed how they valued the differing levels of expertise and effort that volunteers contributed to their projects. This came up in how they interacted with, talked about, and designed their projects for volunteers.

Project managers actively recognized the skills, expertise, and effort that volunteers brought to their citizen science projects. P1, P6, P7, P8, and P11 described how volunteers often had scientific or professional backgrounds that allowed them to contribute at a deeper level than typical volunteers. Some project managers distinguished and had different kinds of interactions with certain volunteers based on their level of expertise or amount of contribution to the project. Terms used to describe these volunteers included "*experts*" (P1), "*elevated users*" (P6), or "*super users*" (P8). P11 described how they have a small number of volunteers who have become "*amazingly expert*" and whom P11 was planning to onboard as junior members of the research team. P8 employs their "*super users*" as expert opinions when there is disagreement in the labeling of an image.

This appreciation ties into many project managers' tolerance of imperfect data output from volunteers. Interviewees assumed volunteers were capable and well-intentioned, attributing low quality data to "human error" (P1). Imperfect data was seen by citizen science project managers as an expected part of data generation that did not significantly affect the quality of the research conducted. For example, P1 said that volunteer observations were "*still very good*" when they had minor errors, and attributed some low quality submissions to an autofill feature that led to inaccurate species tagging. P5 felt that these transcription errors didn't even really matter, while P6 actually viewed them as assets, arguing that even having a small amount of the transcription done on a given page gets "*more eyes on that page, which will then help us to fix or correct or further transcribe that page.*" P3 argued the human intuition of volunteers for visual tasks was still far superior to computational recognition methods.

In short: The above findings connect back to a general sense of respect and appreciation that project managers expressed for their volunteers during our interviews. The fact that project managers spoke thoughtfully about their volunteers' expertise and contributions — and about designing their projects for their volunteers in general — reflects this attitude. P7 captured the core of project managers' respect for volunteers: "*if it weren't for volunteers, [the project] would just stop cold in its tracks.*"

5 DISCUSSION

Our study, examining the practices of citizen science project managers, highlights the complexity of crafting and maintaining positive long-term relationships with crowdworkers. Paid crowd work is often seen as lacking agency and enjoyability, e.g., [34, 41, 52, 75], even sometimes leading to grievous harm [71]. In contrast, citizen science volunteers find the same kinds of data work (image annotation and labeling, transcription, etc.) meaningful enough to contribute voluntarily. In large part, these positive experiences are fostered by the approaches and practices of citizen science project managers who engage with volunteers in a way crowdworking requesters do not. We reflect on these tactics employed by citizen science project managers, observing that they cultivate intrinsic motivation and foster collaborative work relationships, but limit the level of agency volunteers have over the scientific process. Further, we turn to crowdworking to suggest how these methods can be transferred and applied to create more meaningful data work tasks.

5.1 Meaningful Data Work

Above, we described the work of project managers to launch and maintain contributory citizen science projects. Our interpretation of these findings centers around three core aspects of meaningful work: cultivating intrinsic interest, social relationships, and participatory power. Naming these three aspects of meaningful work allows us to reflect on the benefits and limitations of strategies for meaningful crowd-sourced data work.

First, our findings show that project managers created opportunities for meaningful work by cultivating intrinsic motivation in volunteers. We choose 'cultivating' here because rather than simply marshaling existing intrinsic interest, our findings indicate ways that project managers captured, maintained, and grew interest through training and education, communication with volunteers, and engagement with the broader community. For example, project managers crafted narratives that linked multiple topics of interest together to generate broader engagement with their projects. Other strategies for cultivating intrinsic motivation included educating volunteers about science methods and topics, communicating the results of their work, and connecting scientific goals to broader impacts. Unlike in traditional crowd work tasks, nurturing volunteer interest effectively is a critical step for citizen science project managers because projects that fail to capture intrinsic interest will not receive attention from volunteers. Though evaluating the efficacy of these strategies was beyond the scope of our study, the rich body of work examining volunteer motivation in citizen science suggests that these intrinsic motivation factors are the primary forces motivating volunteers [4, 21, 22, 38, 82] — something that the project managers we interviewed understood and utilized. In addition to attracting volunteer data workers, cultivating intrinsic interest also served the participatory goals of citizen science, to foster long-term engagement with science beyond participation in the project. The synergy was enabled by the alignment of scientific and participatory goals discussed in Section 4.1, which speaks to both the productivity and democracy views of citizen science [76].

In addition to cultivating intrinsic motivation, we found that the work of project managers supported respectful and reciprocal relationships between citizen science project managers and their volunteers. Our observations stand in stark contrast with crowd work, where workers are often sidelined, minimized, and dehumanized [51, 52, 65, 74, 75]. We found that project managers fostered relationships through communication with volunteers and reciprocal feedback loops, creating an environment of flexibility and autonomy. These characteristics are core values of meaningful work because they uphold workplace dignity and freedom by giving individuals the ability to determine for themselves how their work develops and contributes to their personal goals [45, 90]. As Keith Breen details, there are many levels of autonomy and freedom that are interdependent with meaning, but all recognize an innate human need to have control and make choices garnering our own direction in life [16]. While traditional management practices undermine these basic principles in exchange for power and control expressed through hierarchies of labor, the flexible nature of crowd-sourced data work creates an opportunity to reimagine how work is defined and measured.

Citizen science platforms enabled these kinds of flexible work arrangements through constant and ongoing communication. We covered many examples of reciprocal communication in Section 4.4: project managers answer questions, provide feedback on task performance, and ask volunteers for feedback on tasks and materials. These relationships rested on the respect and gratitude that project managers held for their volunteers. We also saw great flexibility from project managers, who accepted many different forms and styles of contributions and designed tasks to take advantage of both short-term and long-term contributions [26]. While project managers were prepared to filter out low-quality volunteer submissions — for example, by comparing volunteer submissions

against one another — interviewees reported that the submissions they received were generally of very high quality, and they praised the abilities of citizen scientists to produce high-quality scientific data. In short, these project managers demonstrated a positive regard for volunteers and their abilities, which is a critical factor of a meaningful work experience. The flexibility and autonomy, ongoing reciprocal communication, and positive regard created an environment for positive relationship building on citizen science platforms.

Despite opportunities for engaging work and positive relationships, critics argue that crowd science does not represent meaningful opportunities for participation in the scientific process. Key to these critiques is the idea that the general public is put in service of scientific goals rather than a truly participatory agenda, in which science would be put in service of the public — this reversal would have science responding to the needs and goals of the public [61]. While our interviews highlight extensive efforts by project managers to cultivate intrinsic interest and foster positive work relationships, power and agency ultimately remained in the hands of professional scientists. This remains a limitation of meaningful work in contributory citizen science. While this project intentionally focused on contributory citizen science projects because these tasks most closely match those of paid crowd work, some citizen science projects afford more control to volunteers by involving them throughout the scientific process. For example, rather than enlisting volunteers as data workers, co-created projects work with members of the general public in defining research questions, developing hypotheses, designing methodologies, interpreting data, and asking new questions [10]. Project managers might further support the meaningful work ideals of flexibility and autonomy by working with members of the public throughout the scientific research process.

Finally, it is important to acknowledge that while crowd science may be a meaningful volunteer opportunity, the lack of compensation means that it is not a stand-in for crowdworkers whose livelihood stems from performing tasks on platforms like Amazon Mechanical Turk [37], many of whom rely on crowd work platforms as a primary source of income [66]. This renders the engagement and fulfillment that some people find in citizen science accessible only to those with the privilege that allows them to choose to spend their time performing unpaid data work. This arrangement helps explain why uneven representation in scientific fields is often reproduced in citizen science [57, 58], despite the work that project managers do to minimize barriers to participation. Though citizen scientists perform similar activities as crowdworkers, only the latter is compensated monetarily for their labor, while for the former, participation is understood as a form of play or enrichment. Throughout our analysis and conversations amongst the authors, we wondered whether participating in citizen science could even be considered work. In many ways, it is unrecognizable from the images of work we hold in our heads: inflexible schedules, performance metrics, strict time requirements, etc. Given this observation, HCI might consider that the future of work is not *work* at all [17]. The lens of meaningfulness is one way to begin to separate ourselves from traditional ideas of what work looks like, where it is performed, and who is executing it. If we seek instead to create meaningful lives that empower individuals to find and pursue their purpose on a daily basis, we can start to consider a future where data work is engaging, enriching, and fulfilling. Though these values are incompatible with crowd work as we know it, citizen science inspires us to reimagine the experience of performing labor in the context of data work.

Based on our interviews, we consider how crowd-sourced data work becomes meaningful through cultivating intrinsic motivation, fostering working relationships, and supporting power and agency. Importantly, we find these qualities of meaningful work are present in citizen science, where volunteers are not paid. However, it is valuable to consider how we might apply the strategies used to coordinate data work in citizen science to imagine more meaningful paid crowd work. Next, we describe our recommendations for designing more meaningful paid crowd work.

5.2 Reimagining Crowd Work through Citizen Science

Paid crowd workers and volunteer citizen scientists complete tasks that are similar in structure, but their motivations for doing so and the social arrangements behind the work vary greatly. We often assume that paid work does not need to be meaningful, but in tasks that require intense concentration, such as data annotation and labeling, making meaningful tasks can be a tool for engagement. Further, work is more than a financial exchange, and as we spend more than a third of our lives at work, it consumes much of our time and energy [87]. Meaningless paid labor reduces work to toil in service of capitalism. A more equal and equitable future means we must enjoy how we spend our time. Furthermore, providing opportunities for meaningfulness in work increases productivity and contributes to higher-quality work [2, 8, 64]. In particular, with regards to data work, when workers understand the larger meaning of the work, they do better work [33]. As in many forms of work, people lose investment when they are alienated from the bigger goal of their work.

Reflecting on the methods detailed by our interviewees, there are several ways crowdworking requesters can make the work of data collection and annotation more meaningful. In Section 4, we reported strategies used by interviewees to manage citizen science projects, resulting in tasks that are engaging and appealing enough to motivate volunteers. Though traditional crowd work is (and should be) paid and, therefore, is not limited to intrinsic motivational factors, requesters can utilize the same strategies to design tasks that are more engaging, interesting, and offer more meaning. In this section, we discuss how strategies used by citizen science project managers might be translated to the more traditional crowdworking space, such as Amazon Mechanical Turk.

Critically, however, we caution that these suggestions of meaningful work are not meant to fundamentally reorient traditional crowdworking tasks as citizen science ones; rather, the goal is to import lessons around creating meaningful work to digital crowdworking platforms as they already exist. Meaningful work should not be understood as a means of displacing compensation – instead, this should be an addition to the monetary compensation that crowdworkers deserve for their labor. Further, citizen science spaces and platforms should not be used to host traditional crowdworking tasks that would appear on for-profit platforms like Amazon Mechanical Turk. Nor should crowdworkers be deprived of potential labor — crowdworking should remain a separate profession, as it currently exists, just with the addition of attributes of meaningful work. As our participants caution, citizen science is not faster, nor is it any easier than producing data through crowd work.

5.2.1 Cultivating Intrinsic Motivation. As we discussed previously, project managers in citizen science rely on intrinsic motivation to capture and maintain the attention of volunteers. The work and strategies behind cultivating intrinsic motivation increase productivity and create opportunities for more meaningful work for participants. We align with others in recommending that crowd work tasks should be designed to be interesting or intrinsically motivating [15]. Based on our conversations with citizen science project managers, we present several concrete options for doing so. First, we recommend that requesters find and use opportunities for learning and education within tasks instead of simply training participants to complete the task. Interviewees crafted educational materials, including videos, written instructions, and FAQs, that educated volunteers about science topics in relation to the training they would need to complete tasks. Secondly, connecting the task to bigger-picture goals and linking it to other fields can help spark and carry interest between fields. Third, communicating updates on the results and impact of contributions from data workers helps give participants a stake in the work and maintains long-term interest. In addition to creating a more meaningful future of work, we believe that these strategies can help increase productivity and data quality.

5.2.2 Fostering Collaborative Work Relationships. Compared to the traditional monetary compensation of crowd work tasks, citizen science project managers rely on the goodwill and interest of their volunteers. Thus, the working relationship between volunteers and project managers is one that is highly cultivated and intentionally nurtured. Supporting longer-term relationships, opening communication between requesters and crowd workers, and approaching crowd workers with trust move towards more collaborative work relationships, shifting the social arrangements that underlie crowd-based data work. While there have been attempts to foster more collaborative spaces for crowd work, e.g., worker guilds [85], it is still not encouraged at the platform level, e.g., by Amazon Mechanical Turk [34].

Many citizen science project managers spoke highly of their volunteers and were familiar and friendly with long-time participants and community members. Notably, these relationships differ from the traditional paradigm of crowd work in which the relationship between a worker and task requester may only last a few minutes in duration, illustrating broad "trends toward extremely short-term contract work" [15]. The short duration of typical crowd work reflects the time pressures that exist in academic publishing and commercial activity. While the push to produce incentivizes high speed, low cost data work initiatives, citizen science projects, which are also subject to conference deadlines and publishing cycles, suggest we might imagine alternative arrangements. Crowd work platforms should consider ways to facilitate long-term engagements between requesters and data workers. Translating this norm from citizen science to crowd work might require requesters, organizations, or platforms to consider relationships beyond a single task. For example, Instead of asking workers to re-qualify for tasks from different requesters, crowd work requesters could lengthen the duration of their working relationship with a pool of trusted workers. One way to do so would be sharing (with the workers' consent) worker IDs with other requesters of similar tasks, e.g., within universities or research institutes, to save workers the trouble of having to continually re-qualify.

Additionally, requesters might consider adopting communication strategies utilized by citizen science project managers. Answering questions, hosting webinars, and asking for feedback from volunteers could be adopted by crowd work, where communicativity of requesters has been a problem [15, 40]. Project managers described being in touch with their participants through forums and message board mechanisms, as well as occasional project-related gatherings and events. While crowdworking is primarily an online discipline, many of those same engagement tools can be used as low-investment ways for requesters to support workers. For example, many crowdworking platforms have associated (un)official forums where workers congregate to share experiences on particular tasks or with particular requesters [40]. Creating open channels for communication also creates opportunities for workers to share discoveries, as we discussed in Section 4.4. These discoveries can be hugely valuable. For example, volunteers in early citizen science project Galaxy Zoo discovered a previously unseen space phenomenon by flagging image features outside of the scope of their original task. Open, reciprocal communication also makes it possible to provide feedback to crowdworkers, something that is widely acknowledged to increase crowdworker performance [15, 23]. Though communicating with the crowd takes time and energy, these forms of interaction are worth engaging with as requesters because, besides giving insight into worker experience, highlighting potential problems or challenges with the tasks' design or directions, and identifying directions for future work, they can also help cultivate relationships with workers that support longer-term engagement. Building ongoing relationships with crowdworkers is among the most effective behaviors for increasing worker satisfaction and reducing turnover [15].

This care also manifests as trust by project managers in volunteers. One place we see citizen science project manager's trust of volunteers was in the way data errors were handled. Repeatedly, project managers in our corpus relayed stories of reviewing project submissions and having

concerns about whether or not a task had been properly completed. Mistakes were seen as inherent to the nature of data work, and project managers defended the efforts and knowledge of volunteers contributing erroneous submissions. In paid crowd work, similar errors could result not only in a crowd worker losing pay for that submission but also being barred from future work. Instead, outlier submissions served as conversation points between volunteers and project managers, and participating in these conversations corrected the submission while simultaneously helping volunteers hone their skills. In crowd work, rejection rationale should be actionable and should be communicated as "fruitful feedback" [56, 67]. Another place where we see a lack of trust in crowd workers is *attention checks*, or simple logical questions or tricks to ensure that workers are paying attention. This does not speak to a culture of trust; rather, it pits workers against requesters, who demand unrequited attention from workers, despite workers who, like any shift-based employee, may have varying attention levels throughout the day, including screen-based fatigue. There are a plethora of ways requesters could re-orient this dynamic, to instead provide practical, trust-based ways to re-focus workers. For example, rather than including multiple CAPTCHAs or attention checks, requesters could experiment with including a minute or two in the paid task session to have workers practice a quick meditation or off-screen activity (such as the "20-20-20 rule"), giving them a chance to refresh or relax.

Considering the lack of trust that characterizes relationships between crowdworkers and requesters, fostering collaborative working relationships in paid crowd work may require a fundamental shift in social arrangements. A key delineation between crowd work and citizen science, as underscored by our findings, is the management of data workers (either crowd workers or citizen scientists) by requesters and project managers. The concept of *work controls* [63], originating from managerial studies, can be used to highlight the differences between these two groups. Bureaucratic control, as a rigid system of hierarchical mechanisms to mandate how work is performed [9, 27] best characterizes paid crowd work, as described by Gerber et al. [31]. On the other hand, citizen science project managers described a management style based on trust and respect for their data workers (citizen scientists). Returning to managerial notions of control, there isn't a perfect match for project managers' style; clan control, in which subordinates are controlled through belief structures and cultural norms [9], seems closest. However, in their own characterizations, the project managers we spoke with did not describe efforts to control citizen scientists (as data workers) as a priority (unlike requesters of paid crowd work [30]), instead focusing on facilitating participation. This is a structural approach that makes direct transition of the practices of citizen science project managers to crowd work requesters difficult. However, creating workplace standards that are based on these concepts can prove valuable to the experience of crowd work requesters and workers both.

One place we might look to as we reimagine relationships between requesters and crowd workers is literature on care. An orientation to care, rooted in ethics but broadly considered in STS, political science, and HCI [20, 32, 46, 54, 55, 83], prioritizes relationality, reciprocity, responsiveness, and plurality [24, 32, 36]. HCI scholars working in data have already turned to care as an orientation [11, 13, 50, 81, 91]. Future work might explore how an ethics of care might inform alternative crowd-based data work that fosters positive social relationships between requesters and crowd workers.

5.2.3 Designing Tasks for Meaningful Data Work. Citizen science tasks reflect a desire for participation and are therefore carefully constructed to be accessible and appealing to participants, whether paid or volunteer, whereas crowd working tasks traditionally prioritize the needs of the task requester. Instead of viewing worker experiences and productivity as conflicting goals, the values and norms of citizen science align the two, as discussed in Section 4.1. The strategies used by our interviewees suggest that productivity and participatory goals have been presented as a

false dichotomy. Citizen science project managers designed tasks that prioritized their volunteers from the beginning, sometimes even shifting project goals to better align with volunteer interests, a practice that was mutually beneficial for project managers and volunteers. While we encourage requesters to do the same, accounting for crowdworker experience from project inception, here we present tweaks to crowd working task design that may make the experience of completing the task more enjoyable to workers, leading to better submission quality.

In line with strategies for minimizing barriers discussed in section 4.2, tasks should be designed to make data work easy and pleasant to complete. For example, unless there is a task-specific requirement to use a certain kind of device, crowdworking requesters should ensure that their tasks are multi-device compatible, as many crowd workers use mobile devices [37]. Further, tasks should prioritize functionality over aesthetics (e.g., accessibility of basic task functions in place of CSS-heavy page elements), given that workers may be in areas with slow or limited connectivity. Finally, requesters should consider whether or not a proposed crowdworking task is actually suited to a given crowd working platform. Despite each crowd working platform having different attributes with regards to features or interaction methodologies between worker and requester, many requesters use a handful of major sites, which see postings for a great assortment of task types. In some cases, the bulk nature of these larger sites may not be suited to tasks that require, for example, reflection and creativity, as site interface or infrastructure may put limitations on engagement types and duration, where a longer-term, more accessible interaction would be desirable.

Finally, task design should consider features that support open communication. Adding a feedback box to tasks that allows workers to comment quasi-anonymously (e.g., only by platform-issued ID number) with concerns or notes on their experience completing the task would allow workers to point out challenges or ambiguity in directions that, once lessened, would help other workers complete the task more satisfactorily. Further, additional compensation, such as paying out a bonus for any bugs or accidental obstacles contained in the task, can both reward careful worker attention and contribute to better task submission quality. Transforming the task into a site of communication could also encourage crowd workers to report discoveries, potentially expanding beyond the scope of the task.

6 CONCLUSION

Researchers in CSCW have long studied the transformation of workplace practices, tracing the impact of technology on entire generations and classes of people. The rise of online platforms and virtual distributed work is only one way that computing has recently transformed the boundaries of work. While there is immense potential to empower workers with these tools and services, we also know they come with significant challenges that can reinforce hierarchies of control and remove meaning from work.

Citizen science projects serve as examples where data-driven systems deliver organizational goals and meaningful experiences for volunteers. As our findings reveal, however, creating a meaningful exchange of labor requires managing work in entirely different ways. The citizen science project managers in our study described how they managed crowd-based data work by aligning scientific and participatory goals, minimizing barriers to participation, engaging communities, communicating with volunteers, training and educating volunteers, and rewarding volunteer contributions, all of which were underpinned by a positive perception of their volunteers. These strategies created opportunities for meaningful work by cultivating intrinsic motivation and fostering collaborative working relationships. Examining these practices highlights opportunities to design for meaningful work in domains like crowd work that are mediated by similar online platforms. The promise of remote wage labor jobs enables new forms of autonomous work as a result of global connectivity and the exchange of information, but we need to carefully examine how these

opportunities shape worker experiences. Otherwise, we risk reproducing extractive and exploitative systems of labor that reduce work to toil and minimize the contributions of workers. In working toward more equitable data work, citizen science helps us reimagine alternative arrangements that are both productive and meaningful.

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