VolunTIERing: Balancing Flexibility, Engagement, and Shared Task Context for Sustainable Online Volunteering

SIMRET ARAYA GEBREEGZIABHER, University of Notre Dame, USA

AVA DECROIX, University of Notre Dame, USA
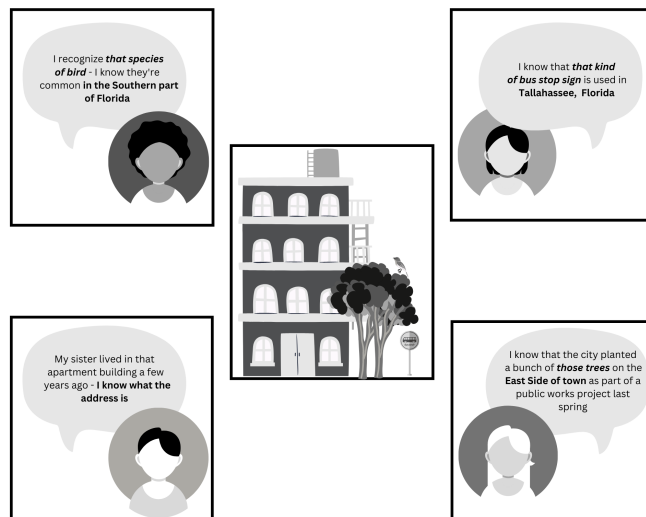
TOBY JIA-JUN LI, University of Notre Dame, USA

Fig. 1. Factors like prior background, domain knowledge, and familiarity with area play a role in volunteer engagement

The reasons why people start volunteering are often different from those that result in their continued involvement. Studies in social psychology reveal that both external and internal factors have a role to play in sustaining motivation and enthusiasm. The goal of existing efforts to integrate AI into work processes has primarily focused on task efficiency and output, and substantial gains have been made in this area. However, volunteering is a unique work environment in that volunteers are not compensated for their time, so volunteer motivation and the enjoyment of the work process are key factors to consider when introducing AI. This opens up a new design space for human-AI collaboration in the realm of volunteer work where we need to explore the trade-off between task efficiency and sustainable worker engagement. In this paper, we explore this design space of balancing between optimizing efficiency and engagement in human-AI collaboration for online volunteer work. We study the case of PhotoMappers [1], a remote disaster mapping

---

[1] https://2020-crowdsourced-disaster-photos-napsg.hub.arcgis.com/

Authors' addresses: Simret Araya Gebreegziabher, University of Notre Dame, Notre Dame, IN, USA, sgebreeg@nd.edu; Ava DeCroix, University of Notre Dame, Notre Dame, IN, USA, adecroix@nd.edu; Toby Jia-Jun Li, University of Notre Dame, Notre Dame, Indiana, USA, toby.j.li@nd.edu.

volunteer initiative in which volunteers search and map publicly available images of damage during the early stages of a disaster. We conducted semi-structured interviews with PhotoMapper volunteers and admin members (n=5) to better understand their workflow, needs, and attitudes toward AI assistance. Our qualitative results reveal the importance of prioritizing the motivation and engagement of volunteers with their tasks, skills, and community. Accordingly, we propose tools designed in this context must 1) balance returns for varying motivators, 2) provide shared task context, and 3) optimize for asynchronous availability and collaboration.

ACM Reference Format:
Simret Araya Gebreegziabher, Ava DeCroix, and Toby Jia-Jun Li. 2023. VolunTIERing: Balancing Flexibility, Engagement, and Shared Task Context for Sustainable Online Volunteering. 1, 1 (February 2023), 10 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

Online and on-ground volunteers play major roles in many social causes [18]. Anderson and Moore [2] find that people volunteer for a variety of reasons, including the desire to help others, self-fulfillment, occupying time, and the need for social interaction. The active participation and contribution of members are key factors that correlate with the success of online volunteer initiatives [32]. Many volunteer initiatives face challenges in recruiting and retaining active contributors [36]. This can be a threat to daily task performance and long-term sustainability. Both external and internal factors can contribute to this problem [20]. Similarly, Ihm and Shumate [15] find that communication and the sense of belonging are two of the main factors contributing to impactful volunteer participation in online settings. Farrell and Brunton [9] find engagement to be more difficult in online settings due to the low entry and exit barriers they may have.

The integration of AI into workflow tools has had a profound impact on productivity and efficiency. The goal of many human-AI tools is to improve performance by improving the efficiency of the task at hand. As these tools continue to play an increasingly significant role in the workforce, it is important to consider not just their technical capabilities, but also how they interact with human workers. Existing efforts to design human-AI collaboration systems emphasize the identification of complementary strengths of humans and machines and use this knowledge to create workflows that maximize task productivity and performance. However, in the domain of volunteer work, engagement and commitment can be just as important as efficiency and performance (Fig. 2). The expectancy theory, which examines why people work, concludes that they do so in order to experience highly valued psychological advantages or payoffs [35]. As a result, individuals anticipate receiving an adequate return to their contribution, and volunteer work is no different. Integrating AI into different volunteer work settings and teams presents a new challenge in balancing task efficiency and task enjoyment, and providing that expected return. A variety of tools are designed and implemented to enable better work engagement and motivation to enable effective and efficient volunteer contribution [12, 29].

In this paper, we study PhotoMappers, a volunteer crowd mapping initiative, as a case study. PhotoMapper volunteers are tasked with processing and obtaining geographic information by soliciting posts and contributions from a large group of people on the Internet, typically Twitter. This information can include things like points of interest, roads, and buildings and is often used to create or update maps for use in navigation, disaster response, and other applications. Remote volunteering platforms typically need to facilitate task completion to a certain standard of quality and at the same time be attractive to new and tenured volunteers. As a result, there is often a trade-off between maintaining high work efficiency and keeping the platform's design simple, engaging, and enjoyable for prospective and existing volunteers. Our ongoing work aims to explore the lived experiences of online volunteers and draw design implications for AI-powered assistive tools. We present a set of design implications for distributed remote volunteers in crisis response scenarios. Preliminary findings suggest that effective collaboration among distributed online volunteers is
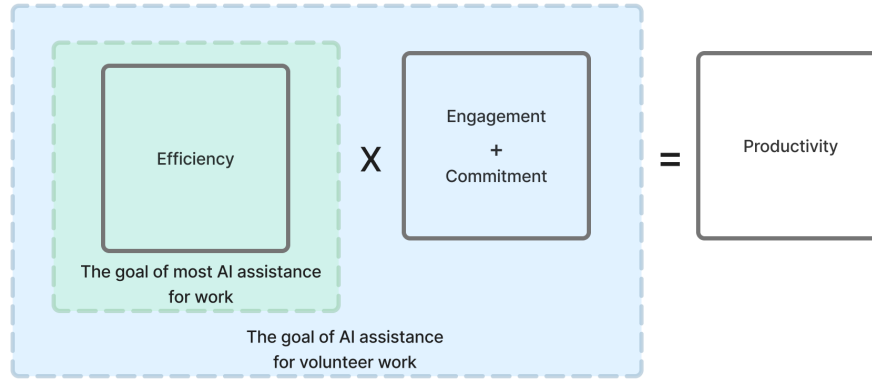
Fig. 2. In the domain of volunteer work, engagement and commitment can be as important as efficiency and performance.

possible, but requires careful planning and coordination. Moving forward, we plan to refine our design implications and implement assistive tools for this context.

2 BACKGROUND

2.1 Crowdsourcing in Non-Profit and Public Engagement

Crowdsourcing is a method of outsourcing tasks, traditionally performed by an employee or contractor, to a large group of people or community (a "crowd"), through an open call [3]. To reach a certain goal, organizations or individuals may elicit contributions or feedback from a large number of people online [6]. This approach has gained popularity in recent years due to the widespread availability of internet connectivity and the ability to reach a large number of people through social media and other online channels. Crowdsourcing has been used in a variety of fields, including information technology, design, and marketing. One of the earliest and most well-known examples of crowdsourcing is the open source software movement, in which developers collaborate online to create and improve software products [23]. In recent years, crowdsourcing has also been used for a wide range of purposes, including product development [26], data annotation [8], and problem-solving [14]. By leveraging the skills and knowledge of a diverse group of individuals, crowdsourcing can lead to the development of new ideas and solutions that may not have been reached otherwise [30].

In addition to its use in the private sector, crowdsourcing has also been adopted by governments and non-profits as a way to engage citizens in the causes that are important to them. For example, the U.S. government has used crowdsourcing platforms such as Challenge.gov to solicit ideas for improving government services and addressing social problems [11]. With the emergence and rapid development of ubiquitous technologies, crowdsourcing has been widely used to create a bottom-up approach for public engagement in social causes [16]. Social media has played a pivotal role in facilitating volunteer lead crowdsourcing for social causes. Through these platforms individuals and organizations

seek participation through small donations from a large number of people, which can add up to significant sums of money (For example, the ALS Association's "Ice Bucket Challenge" campaign [2], which raised awareness and funds for research on Amyotrophic Lateral Sclerosis (ALS) and was able to raise over $115 million), and allowing people to share their skills and expertise towards a common goal. Although crowdsourcing has become a popular method for businesses and organizations to tap into the collective intelligence and resources of a global network of individuals, the major focus remains to tackle independent tasks that require little to no expertise. For example, companies such as Amazon Mechanical Turk [4] and CrowdFlower [34] that pay users to complete tasks ranging from data entry to image tagging.

2.2 Event-centric crowdsourcing: The PhotoMappers Case

Crowdsourcing for humanitarian or social causes is becoming more popular due to the volume of data produced following significant events. For instance, event-centric crowdsourcing is employed after natural disasters to gather data on the impacted areas, offer assistance, and organize first responders [37]. During an active disaster a great deal of information is generated and spread via social media. Responders and other stakeholders can take advantage of the large and frequent data created by social media to gain a better understanding of the situation on the ground [27]. Twitter and Facebook, for example, have been used extensively to share information about an active crises [19].

Using crowd intelligence is especially important for natural and man-made disasters. During this time, geospatial data is constantly changing [13] making it hard to understand what is happening on the ground. Recently, satellite imagery has been extensively used to assist crowd-mapping [24, 38, 40]. However, the accuracy and completeness of satellite mapping is greatly determined by the topography and characteristics of the locations being mapped. Therefore, active human contribution is required to gain full situational and geospatial awareness. Different groups of stakeholders sometimes make initiatives to map areas before and after a crisis. Volunteered "mapping sprees" are widely used to organize and pull community efforts of digital volunteers together for this cause. In most cases of situational mapping field work has a substantial role to play in the completeness of the map [39]. The *PhotoMappers* partnership is a collaboration between URISA's GISCorps, the National Alliance for Public Safety GIS (NAPSG) Foundation, and CEDR Digital Corps. The PhotoMappers project brings together US-based volunteers to search social media and news outlets for publicly shared photos of on-the-ground conditions and damage in areas affected by natural disasters. These photos are used to improve situational awareness and inform response efforts. The PhotoMappers project has been ongoing for five years and has been successful in providing valuable information about disasters to responders and other stakeholders.

2.3 Towards sustainable remote volunteering

Both internal and external factors contribute to the success of volunteer initiatives. Internal factors refer to the personal motivations and factors that influence a volunteer's decision to continue their involvement in a volunteer initiative. These can include factors such as personal values, skills, and interests, as well as the volunteer's level of commitment and satisfaction with the initiative. On the other hand, external factors refer to the social and environmental context in which the volunteer initiative takes place. These can include factors such as the sense of belonging, community, and relatedness that a volunteer experiences as a result of their involvement in the initiative. While internal factors play a big role in the continual involvement of volunteers, external factors like sense of belonging, community, and feeling related to the cause play an equally important role in sustaining engagement [33]. This highlights the heterogeneity

---

[2]https://www.als.org/stories-news/ice-bucket-challenge-dramatically-accelerated-fight-against-als

of motivators and the challenges associated with defining and measuring project success in citizen science projects. According to the findings of Graham et al. [10], project success and public engagement are interdependent and cannot be considered in isolation from one another.

3 FORMATIVE STUDY

To better understand the current practices and challenges of online volunteers in the context of photomapping, we conducted a series of interviews and contextual inquiries with 5 members of PhotoMappers (3 women, 2 men). Of the 5 volunteers, 3 were PhotoMappers volunteers, 1 was an admin member, and 1 was a technical support member of the organization. In particular, the formative study aims to gather information on (1) How volunteers collaborate with each other to create situational awareness during natural disasters, (2) What are the challenges and opportunities for collaboration during on-the-fly on-boarding of new volunteers, and (3) What motivates online volunteers to join the cause and stay in the cause.

3.1 Study Protocol

The study was conducted through a series of semi-structured interviews and contextual inquiry [17] following Hurricane Ian [3]. A few weeks prior to the interview, all participants were actively working on PhotoMappers' crowd mapping efforts. While one interview was conducted through email, the other four interviews were conducted via video calls lasting approximately 45 minutes. The contextual inquiry involved observations of the participants as they carried out their photomapping tasks or gave a walk through of their recent activity. A typical PhotoMappers activation starts a few minutes or hours after a natural disaster occurs and may last up to a few hours or days. Depending on the severity and extent of the situation, the admin team sends out activation emails to registered volunteers. Volunteers typically take up either a role of finding relevant pictures on social media and adding them to a queue or selecting pictures from the queue and locating and tagging them on a map. Every single location added by volunteers goes under a validation process by trained volunteers, and all photos labeled *'invalid'* for not meeting certain quality standards are removed. This process of finding and validating the pictures helps to map the extent of the disaster. Once all of the pictures in the queue are validated and added to the map, the data is provided to emergency responders, NGOs, and other organizations that are helping with disaster relief.

We used inductive qualitative coding to analyze the interview data. We began by analyzing observations from the contextual inquiry, in which the interview coordinator pointed out interesting observations that were then discussed by the research team. Ideas around reasons for motivation, the starting barrier for new volunteers, and observed inefficiencies in the work pipeline were discussed during this time. Following this two members of the research team separately coded the interview transcription based on the discussed ideas.

3.2 Key Insights

KI1: Volunteers are driven by competing internal and external factors. Volunteering, whether online or in person, is often motivated by a desire to make a positive difference in the world and to contribute to the well-being of others. Generally, two forms of reasoning are put forward in service-based volunteering. Whether people are motivated by altruism or some form of personal gain has been in disagreement [21]. For many volunteers, the sense of purpose and the opportunity to make a difference in the lives of others, among other reasons, is a key motivation for getting

---

[3]https://www.nesdis.noaa.gov/news/hurricane-ians-path-of-destruction

involved and contributing. However, according to Callender et al. [5] external factors like relevant training, burnout, being undervalued can contribute to the tenure of on-ground volunteers. PhotoMappers as an online volunteering initiative requires a strong attention to detail and the ability to work quickly and effectively under pressure. Some volunteers expressed the sense of purpose and the opportunity to make a difference in the lives of others as one of the main motivations to start volunteering and contributing. *"Yes! I will definitely keep volunteering because I have seen how much the emergency managers at every level of government rely on our work and it feels good to make a difference during a natural disaster"* (P4). Participants also indicated additional factors like convenience and flexibility to play a role in their continued involvement in PhotoMappers. *"I wanted to give back because I couldn't be there in person, but it's definitely something I do again for other disasters" (P1).* Apart from altruism, personal factors like gaining new skills or exercising already acquired skills in a particular area, such as social media or GIS. *"I work for emergency services in my home county. [...] It is not something that's too difficult for me. I mean I have an IT background from before, got into emergency services too. So, moving my way around platforms like that isn't a challenge for me." (P5)* Participants also noted that working on particularly challenging tasks could also be a motivating factor, as they enjoyed the puzzle-like nature of figuring out where a difficult-to-identify photo was taken

KI2: Collaboration and coordination are needed to develop a sense of belonging in dynamic and distributed volunteer work. In a distributed and dynamic setting, where team members may not be physically located in the same place or work schedules, it can be especially important to have clear lines of communication and to establish processes for staying coordinated and connected. Volunteers generally collaborated for reasons like answering a question. The admin team observes the potential of using a communication pipeline to ensure and maintain the motivation of volunteers. *"That has been a huge reason that I think it continues to work so well. So we have multiple slack channels. We have one giant one for all the volunteers. I will learn how the data is being used. So I will report that back in the slack channel." (P2).* This was reiterated by a volunteer as well *"It was rewarding because you know, it was tough, not being able to be there. But it was nice, knowing that you know what I was doing was going to help people that were there. So that was. It was rewarding to know that, you know they were still helping people on around about like, because you can see that you could see the map of where everything was posted, and you the more time everybody spent on it, the more you could see the post. So the the dots are where everything was mapped. So it was cool to see it slowly move." (P1)* Participants indicated volunteering online can miss the sense of community and personal connection that can come from working with others in person. Participants sought active collaboration by reaching out to other volunteers and admins to ask for help. *"They[volunteers] would say, hey, I am working on line number ten. Does anybody have any insight into this photo or anybody recognize anything in this photo? I have a hard time with it. And based on that, sometimes people like Oh, I've been there. I know what that is, or just the fresh set of eyes can help when you are stuck." (P1)*

KI3: Volunteers contribute their time around their other commitments. Many volunteers balance their volunteer work with their paid jobs and other commitments, making it important for tasks to be flexible and completed around the volunteers' schedules. Participants mentioned that online volunteering fit their schedule and allowed them to work on a project at their own pace and complete microtasks such as identifying a single photo during very small breaks, making it a convenient and rewarding way for them to contribute their time and skills. *"I was looking for a way to earn contribution points for the GISP certification, so I signed up to volunteer. This was the perfect way for someone as busy as myself to work on a volunteer project because there was no time commitment, no set meetings and could be done whenever I found time during an activation." (P4).* This type of flexibility is important for attracting and retaining volunteers, as it allows them to be engaged without adding undue stress or time commitments to their already busy schedules. However

with tasks that are time sensitive as disaster situational awareness, participants raised the concern that volunteers not be overloaded with tasks they cannot complete in a timely manner, which could hurt their morale and make them less likely to volunteer in the future. This presents a challenge for reducing interdependence and complexity of tasks, while still meeting the needs of any given disaster response.

KI4: Factors like prior background, domain knowledge, and familiarity with the area make some tasks easier than others. Having prior knowledge or experience in a certain domain or location can help a person understand the task more easily and make it easier to complete. *"I spent a lot of time in Fort Myers for a hurricane in 2017. So I am familiar with Fort Myers and some other buildings. So it was easy to pick out now. I have seen this building before, you know, like this one got damaged last time too, and like some of the larger structures that were more known." (P5).* However, finding and recruiting volunteers with the right skills and expertise can be a challenge. In addition, different tasks and situations may require different levels of knowledge or expertise. For example, when responding to a hurricane, a person with a background in meteorology or emergency management may be better suited for the task than someone without such knowledge.

3.3 Design implications

3.3.1 Designing automation for efficiency with motivation and engagement in mind. Balancing between the different external and at times conflicting factors that motivate volunteers is an important feature that contributes to volunteers' continued engagement and satisfaction. It is also important to acknowledge that volunteers may have different levels of commitment and availability, and to be flexible in accommodating their schedules and preferences. Our study found that although motivators such as giving back to society and past experience were frequently cited by our participants, they also emphasized the importance of other motivators such as having fun, engaging with the task, and interacting with fellow volunteers (KF1). Consequently, in order to improve volunteers' engagement and satisfaction, and to create a more positive and productive volunteering experience, it is essential to design tools that take into account the various motivators in volunteer work. To achieve this goal in human-AI tools designed for task performance, we recommend incorporating gamification. Gamification involves incorporating game-like elements into non-game contexts [22], such as volunteer work, in order to increase user engagement and motivation [7]. This can encourage social interaction between volunteers, creating a sense of community and prolonged collaborative work [1].

In line with prior work [31], internal motivators of wanting to acquire new skills or exercise acquired skills are important for long-term engagement. To this end, we identify the potential to optimize task and skill matching for better engagement and task performance. Matching volunteers with tasks that align with their skills and interests can increase their motivation and task performance. Volunteer skill sets can further be used to facilitate collaboration with consideration to complementary availability, skills, and task needs.

3.3.2 Providing shared task context in collaborations. Online volunteer work can be challenging because it often lacks the shared context and collaboration opportunities of in-person volunteering [28]. Although the tasks in photomappers resemble micro-tasks, where workers solely focus on the tasks at hand [25], volunteers indicated the need to understand the overall goals and objectives of the task and how their contributions fit into the bigger picture (KF1). To this end, we identify 1) shared general context through continuous feedback for event-wide awareness, and 2) shared workspace context through collaborative navigation, and virtual collaboration spaces for task-wide awareness to be important.

3.3.3 Optimizing for asynchronous availability. Volunteers in our study indicated their ability to contribute to a task at different times and from different locations (KF2, KF3). This is particularly important in the context of virtual

volunteering, where volunteers may not be able to contribute to a task in real-time due to other offline commitments. To address this, tools should be designed to provide flexibility in terms of task completion and allow volunteers to work and collaborate at different paces. This can be achieved by providing asynchronous communication channels, such as chatbots or asynchronous peer-working, that volunteers can use to interact with the organization or other volunteers. To ensure the successful adoption of AI tools in settings characterized by varying volunteer schedules and locations, it is essential to design tools that provide a seamless and flexible experience for volunteers. This means creating tools that can accommodate different schedules and preferences, such as by providing self-paced training materials and activities that volunteers can complete at their own convenience. Additionally, the tools should include asynchronous communication channels that allow volunteers to interact with the organization or other volunteers at different times and from different locations.

4   THE ROLE OF TRUST IN AI ASSISTED VOLUNTEER WORK

AI can be utilized to assist in photomapping by facilitating collaboration between volunteers, as well as by partially automating certain aspects of the process. In the context of PhotoMappers potential areas of automation include task screening and assignment, in which tasks are assigned to the most suitable volunteers to ensure both engagement and efficiency. AI can also be used to automatically monitor the quality of volunteer work, such as through automated grading or feedback systems. This can help to ensure that volunteer work meets the required standards and provide constructive feedback to volunteers. In the context of AI-assisted volunteer work, it is crucial to maintain transparency and ensure that volunteers understand how the AI system is making decisions and performing tasks. End-to-end black box models, with no clear explanations for their decisions, can erode trust in the AI system and ultimately lead to disengagement among volunteers. By contrast, a more transparent AI assisted tools can help to build trust and foster engagement among volunteers, leading to more efficient and effective volunteer work.

4.1   Trust in Human-AI Collaboration

The concept of trust and reliability in human-AI teams takes on new significance in the context of volunteer work. Volunteer work, unlike paid work, relies on the motivation and commitment of individuals to contribute their time and skills. Moreover, time and resources can be limited, making it crucial that volunteers feel that their efforts are making a tangible difference. By utilizing trustworthy and reliable AI systems, volunteers can feel confident that their contributions are being used effectively and efficiently, further motivating them to continue their work. The success of volunteer projects can hinge on the ability of tools and systems to engage and motivate volunteers.

4.2   Trust in AI-Facilitated Human-Human Collaboration

Human-human collaboration is a critical component of volunteer work. Human-human collaboration helps to build a sense of community and shared purpose among volunteers, fostering a sense of belonging and motivation to contribute to the project. In this context, AI can serve as a tool to support and enhance human-human collaboration. Ultimately, the objective of building trust in AI-facilitated human-human collaboration is to optimize and streamline collaborative efforts among volunteers, leading to more efficient and effective volunteer work. By prioritizing trust in the development and implementation of AI assistance tools, organizations can build a stronger foundation for successful volunteer engagement. The discussion in this workshop can provide valuable insights and ethical considerations for designing AI-assisted tools in the context of remote volunteer work. The workshop will provide an opportunity to learn from experts in the field, share experiences with other practitioners, and explore best practices for building and maintaining

trust in systems for this important task. In addition, the discussion raised through this work can explore questions such as: How can AI be integrated into volunteer work in a way that enhances human-human collaboration, human-AI collaboration and supports volunteers in achieving their goals? What are the potential risks and challenges associated with using AI in volunteer work, and how can they be mitigated? How can AI systems be designed to be transparent, explainable, and accountable, in order to build trust and reliability among volunteers?

REFERENCES

[1] Raed S Alsawaier. 2018. The effect of gamification on motivation and engagement. *The International Journal of Information and Learning Technology* 35, 1 (2018), 56–79.

[2] John C Anderson and Larry F Moore. 1978. The motivation to volunteer. *Journal of Voluntary Action Research* 7, 3-4 (1978), 120–129.

[3] Daren C Brabham. 2008. Crowdsourcing as a model for problem solving: An introduction and cases. *Convergence* 14, 1 (2008), 75–90.

[4] Michael Buhrmester, Tracy Kwang, and Samuel D Gosling. 2016. Amazon's Mechanical Turk: A new source of inexpensive, yet high-quality data? (2016).

[5] Matthew Callender, Kathryn Cahalin, Sam J Cole, Luke Hubbard, and Iain Britton. 2020. Understanding the motivations, morale, and retention of special constables: findings from a national survey. *Policing: a journal of policy and practice* 14, 3 (2020), 670–685.

[6] Ed H Chi and Michael S Bernstein. 2012. Leveraging Online Populations for Crowdsourcing [Guest editors' introduction]. *IEEE Internet Computing* 16, 5 (2012), 10–12.

[7] Sebastian Deterding. 2012. Gamification: designing for motivation. *interactions* 19, 4 (2012), 14–17.

[8] Roberto Di Salvo, Daniela Giordano, and Isaak Kavasidis. 2013. A crowdsourcing approach to support video annotation. In *Proceedings of the International Workshop on Video and Image Ground Truth in Computer Vision Applications*. 1–6.

[9] Orna Farrell and James Brunton. 2020. A balancing act: a window into online student engagement experiences. *International Journal of Educational Technology in Higher Education* 17, 1 (2020), 1–19.

[10] GG Graham, J Cox, Brooke Simmons, Chris Lintott, Karen Masters, A Greenhill, and K Holmes. 2015. How is success defined and measured in online citizen science: a case study of Zooniverse projects. *Computing in science and engineering, PP (99)(22). ISSN* (2015), 1521–9615.

[11] Taha Hameduddin, Sergio Fernandez, and Mehmet Akif Demircioglu. 2020. Conditions for open innovation in public organizations: Evidence from Challenge. gov. *Asia Pacific Journal of Public Administration* 42, 2 (2020), 111–131.

[12] Paul A Harris, Kirstin W Scott, Laurie Lebo, NikNik Hassan, Chad Lighter, and Jill Pulley. 2012. ResearchMatch: a national registry to recruit volunteers for clinical research. *Academic medicine: journal of the Association of American Medical Colleges* 87, 1 (2012), 66.

[13] Billy Haworth and Eleanor Bruce. 2015. A review of volunteered geographic information for disaster management. *Geography Compass* 9, 5 (2015), 237–250.

[14] Michael Howlett. 2019. *Designing public policies: Principles and instruments*. Routledge.

[15] Jennifer Ihm and Michelle Shumate. 2022. How Volunteer Commitment Differs in Online and Offline Environments. *Management Communication Quarterly* (2022), 08933189211073460.

[16] Qijun Jiang, Frank Kresin, Arnold K Bregt, Lammert Kooistra, Emma Pareschi, Edith Van Putten, Hester Volten, and Joost Wesseling. 2016. Citizen sensing for improved urban environmental monitoring. *Journal of Sensors* 2016 (2016).

[17] Holtzblatt Karen and Jones Sandra. 2017. Contextual inquiry: A participatory technique for system design. In *Participatory design*. CRC Press, 177–210.

[18] Anne Kaun and Julie Uldam. 2018. 'Volunteering is like any other business': Civic participation and social media. *New Media & Society* 20, 6 (2018), 2186–2207.

[19] Arshdeep Kaur. 2019. Analyzing twitter feeds to facilitate crises informatics and disaster response during mass emergencies. (2019).

[20] Lincoln R Larson, Caren B Cooper, Sara Futch, Devyani Singh, Nathan J Shipley, Kathy Dale, Geoffrey S LeBaron, and John Y Takekawa. 2020. The diverse motivations of citizen scientists: Does conservation emphasis grow as volunteer participation progresses? *Biological Conservation* 242 (2020), 108428.

[21] Michael Locke, Angela Ellis, and Justin Davis Smith. 2003. Hold on to what you've got: the volunteer retention literature. 5, 3 (2003).

[22] Andrzej Marczewski. 2013. *Gamification: a simple introduction*. Andrzej Marczewski.

[23] David L Olson and Kirsten Rosacker. 2013. Crowdsourcing and open source software participation. *Service Business* 7, 4 (2013), 499–511.

[24] Ruiliang Pu, Shawn Landry, and Qiuyan Yu. 2018. Assessing the potential of multi-seasonal high resolution Pléiades satellite imagery for mapping urban tree species. *International Journal of Applied Earth Observation and Geoinformation* 71 (2018), 144–158.

[25] Alexander J Quinn and Benjamin B Bederson. 2011. Human computation: a survey and taxonomy of a growing field. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 1403–1412.

[26] Daniela Retelny, Sébastien Robaszkiewicz, Alexandra To, Walter S Lasecki, Jay Patel, Negar Rahmati, Tulsee Doshi, Melissa Valentine, and Michael S Bernstein. 2014. Expert crowdsourcing with flash teams. In *Proceedings of the 27th annual ACM symposium on User interface software and technology*. 75–85.

[27] Hernan Sarmiento and Barbara Poblete. 2021. Crisis communication: a comparative study of communication patterns across crisis events in social media. In *Proceedings of the 36th Annual ACM Symposium on Applied Computing*. 1711–1720.

[28] Hamed Seddighi, Ibrahim Salmani, Polina Ermolaeva, Olga Basheva, and Mehrab Sharifi Sedeh. 2020. The challenges and opportunities of online volunteering for COVID-19 response in Iran: A qualitative study. (2020).

[29] Joshua Paolo Seguin, Delvin Varghese, Misita Anwar, Tom Bartindale, and Patrick Olivier. 2022. Co-designing Digital Platforms for Volunteer-led Migrant Community Welfare Support. In *Designing Interactive Systems Conference*. 247–262.

[30] Ethan Seltzer and Dillon Mahmoudi. 2013. Citizen participation, open innovation, and crowdsourcing: Challenges and opportunities for planning. *Journal of Planning Literature* 28, 1 (2013), 3–18.

[31] Filipa Silva, Teresa Proença, and Marisa R Ferreira. 2018. Volunteers' perspective on online volunteering-a qualitative approach. *International Review on Public and Nonprofit Marketing* 15 (2018), 531–552.

[32] Kate Starbird and Leysia Palen. 2011. " Voluntweeters" self-organizing by digital volunteers in times of crisis. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 1071–1080.

[33] Athanassios D Strigas and E Newton Jackson Jr. 2003. Motivating volunteers to serve and succeed: Design and results of a pilot study that explores demographics and motivational factors in sport volunteerism. *International Sports Journal* 7, 1 (2003), 111.

[34] Chris Van Pelt and Alex Sorokin. 2012. Designing a scalable crowdsourcing platform. In *Proceedings of the 2012 ACM SIGMOD International Conference on Management of Data*. 765–766.

[35] Victor Harold Vroom. 1964. Work and motivation. (1964).

[36] Jeni Warburton, Melissa Moore, and Melanie Oppenheimer. 2018. Challenges to the recruitment and retention of volunteers in traditional nonprofit organizations: A case study of Australian meals on wheels. *International Journal of Public Administration* 41, 16 (2018), 1361–1373.

[37] Kirsty Watkinson, Jonathan J Huck, and Angela Harris. 2022. Centaur VGI: An evaluation of engagement, speed, and quality in hybrid humanitarian mapping. *Annals of the American Association of Geographers* 112, 8 (2022), 2373–2392.

[38] Chenghai Yang, James H Everitt, and Joe M Bradford. 2006. Comparison of QuickBird satellite imagery and airborne imagery for mapping grain sorghum yield patterns. *Precision Agriculture* 7, 1 (2006), 33–44.

[39] Godwin Yeboah, João Porto de Albuquerque, Rafael Troilo, Grant Tregonning, Shanaka Perera, Syed AK Ahmed, Motunrayo Ajisola, Ornob Alam, Navneet Aujla, Syed Iqbal Azam, et al. 2021. Analysis of openstreetmap data quality at different stages of a participatory mapping process: Evidence from slums in Africa and Asia. *ISPRS International Journal of Geo-Information* 10, 4 (2021), 265.

[40] Lin Yuan, Ruiliang Pu, Jingcheng Zhang, Jihua Wang, and Hao Yang. 2016. Using high spatial resolution satellite imagery for mapping powdery mildew at a regional scale. *Precision Agriculture* 17, 3 (2016), 332–348.