RESEARCH STATEMENT

Open collaboration platforms are increasingly used to solve complex organizational problems. Examples of open collaboration include citizen science projects such as Galaxy Zoo, where professional astronomers and amateurs collaborate to categorize galaxies and OpenIDEO, a social impact platform where people contribute solutions to solve global challenges in areas such as food security and health. Open collaboration has been quite successful; amateur astronomers in Galaxy Zoo have discovered new astronomical phenomena, and through OpenIDEO, Amnesty International was able to engineer an encrypted app that allows users to report unlawful political detentions. Both advances in information and communication technologies and the availability of a globally distributed network of people (*the crowd*) have helped facilitate the rise of open collaboration. The utility of open collaboration platforms will be further amplified by involving crowds in increasingly complex organizational activities that are facilitated by technologies that enhance the user experience.

My research contributes knowledge about the socio-technical design of open collaboration platforms to improve user experiences and increase user performance. Humans are a crucial element of open collaboration; thus, any research that seeks to improve open collaboration platforms must center the human perspective. My research exemplifies such an approach by investigating the technologies and interactions that enhance volunteer learning and motivation in virtual citizen science (VCS) projects. Through methods such as interviews, focus groups, and analysis of digital trace data, my research documents human experiences and offers design recommendations to software developers. I also assess the efficacy of design epistemologies from fields such as psychology and organizational studies to evaluate volunteer learning and motivation. In evaluating design epistemologies, I augment interfaces and evaluate human responses through online field experiments.

Human Behaviors in Virtual Citizen Science Platforms

Virtual citizen science projects are a popular method for conducting scientific research. Virtual citizen science (VCS) projects facilitate collaboration on large-scale scientific research between professional scientists and amateur volunteers. Citizen scientists have successfully contributed novel scientific findings, and artifacts produced by citizen scientists are regularly used by professionals to accelerate scientific discoveries. To date, my research has focused on providing design recommendations through exploring human experiences in Zooniverse, a digital platform that hosts more than 100 citizen science projects and has more than 1 million registered accounts. Zooniverse projects allow scientists to upload scientific datasets and solicit assistance from the crowd to analyze the data.

Learning and motivation are two critical areas of research dictating the success of VSC projects. Since most citizen scientists are amateur volunteers with little knowledge about the technical infrastructure supporting their participation or the science subject matter, insights into how citizen scientists acquire procedural knowledge, technical competence, and learn the subject matter is essential. My research investigates the learning process of citizen scientists by documenting the use and assemblage of socio-technical features that support learning. To that end, I have authored several publications directed towards describing the learning process. In one study, I examined the sociomaterial arrangements through which specific modes of participation are enacted. Using digital trace data, I analyzed the interactions of citizen scientists during different stages of involvement with a VCS project. The results of my analysis depicted a learning process that is evolving. During early phases of interaction, people relied on authoritative interactions using resources constructed by the science team and during the later stages of involvement, people relied on social participation, using resources that are constructed by other learners (i.e., discussion threads where work practices are detailed or *practice proxies*) and themselves (i.e., through curating and organizing in personal notebooks) to enhance their learning. The findings emphasized the decreasing reliance on non-authoritative resources and increasing attention on social participation.

Furthermore, the findings point to the dual role of technologies that support social participation, underscoring findings from a previous study I conducted. Experienced citizen scientists create practice by producing detailed descriptions of their data analysis practices on more challenging tasks for which there are no formal learning resources. The accounts created by experienced citizen scientists serve as opportunities for observing practice by inexperienced citizen scientists. Currently, VCS platforms make no distinction between experienced and inexperienced citizen scientists; therefore, inexperienced people need to spend time discovering the appropriate

resources. The recommendations from these studies is that to enhance learning, software developers should engineer technologies that appropriately match learners with user-generated content created by other learners.

Understanding what motivates people to participate in VCS projects is crucial for attracting new citizen scientists and retaining existing ones. My research also identifies factors that positively influence human motivation. Historical research on motivation has produced a glut of empirical studies that attest to the efficacy of various design choices and their motivational outcomes. While these studies address motivation in the physical world, my research implements and evaluates motivational designs in virtual spaces. My dissertation examined how novelty theory influences citizen scientists' contribution behaviors in three VSC projects. Novelty theory posits that objects possessing a novel attribute will induce curiosity, leading to increased attention towards the object. Novelty theory was operationalized as *novelty cues* or messages that revealed when a citizen scientist was the first person to see and analyze the data. I hypothesized that novelty would motivate citizen scientists to spend more time and complete more work in the project. The hypothesis was confirmed only for some projects; however, I argued that mediating factors that were not measured, such as differences in a person's sensitivity to novelty and existing features of a system, e.g., gamification may be sufficiently motivating.

The Future of Citizen Science

The arc of scientific research points towards an ever-growing universe of new automated scientific-data collection instruments, increasing the amount and variety of data. As an example, to handle the potentially 2 million daily alerts from the new Large Synoptic Survey Telescope (LSST), a recent proposal was submitted to develop VSC with real-time data analysis by citizen scientists. Such plans will benefit large-scale scientific research projects by involving amateurs in elaborate data analysis work and other advanced tasks such as data curation and interpreting findings. Solving the challenges associated with new methods of data analysis do not exist in isolation and are a part of a broader set of challenges, including designing technologies to support distributed communication, coordination of work, and collaboration among stakeholders. Frameworks are also needed to address problems such as information transfer, data integration, and data management. Learning from human experiences and expertise is crucial to designing future technologies and systems to support advanced work. To that end, in the coming year, I will expand my research program to include two new areas of research - *a human-centered approach to designing VSC tasks/workflows and changes in the conduct of scientific research that are occasioned by VCS artifacts.*

Engaging citizen scientists in advanced work is becoming increasingly common in VCS platforms, as citizen scientists are asked to engage in activities such as composing academic articles and conducting independent data analysis. Unfortunately, few VCS platforms have developed the infrastructure to support the types of communication and coordination required to execute advanced tasks. Modern VCS design epistemology emphasizes notions such as designing for scale, meaning to make VCS tasks available to citizen scientists, the professional scientists must adapt their work to fit existing VCS templates. As an example of this misalignment can be found in Gravity Spy. In Gravity Spy, in addition to classifying images, a task that is supported by the current technical infrastructure, citizen scientists are now asked to curate the glitches and supply new labels to the glitches, a task not supported by the existing technical infrastructure. Influencing the design of VSC through the use of human-centered design principles will help establish a tighter link between the needs of scientists and the usability of VSC artifacts. As one example, through interviews and participant observations, my research found that citizen scientists are quite enterprising when asked to execute tasks that aren't supported by the system. People employ a diverse assemblage of technologies, e.g., Google Drive, to achieve their goals. My observations of citizen scientists led to several suggestions, such as new tools for image curation and mechanisms for coordinating activities between citizen scientists working on similar tasks. Engineering VCS platforms, through human-centered design principles, focusing on the needs of professional scientists and the abilities of citizen scientists, will influence the design of future VCS platforms.

Close examinations of changes to scientific practice in the context of VCS artifacts are also missing from the field. As professional scientists use VCS artifacts, understanding the challenges they encounter and how practice changes will help plan for the future of scientific research with crowds. These investigations will focus on the procedures and routines employed by scientists to make VCS artifacts usable as they integrate them into existing practices. To date, I have conducted ten interviews with professional scientists in four projects. The preliminary analysis depicts a lack of formalized procedures to integrate VSC data meaning some data become unusable. As an example, the Gravity Spy project struggles to convince its astrophysics to use VCS data, with many scientists

believing other approaches such as machine vision are sufficient. A deeper understanding of the challenges faced in using VCS can help better equip scientists to integrate VCS artifacts into practice. The research has implications beyond VCS, however, as it parallels other instances where new technologies (e.g., the use of machine learning and artificial intelligence workplace settings) and methods are used to achieve organizational goals. Solving the challenges presented above requires bridging principles and methodologies in human-centered design and fields like science and technology studies (STS). The design component points to the deconstruction of work and participatory design with scientists while the STS examines the networks, re-configurations, tools, routines, which VSC artifacts become instantiated in practice.