Defining one's role in citizen science

An investigation of the roles, perceptions and outcomes of citizen scientists and public engagement in science facilitators

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ABSTRACT

Citizen science (formally public participation in science research) has emerged in recent years as an innovative and interactive tool for engaging many diverse groups in science and research. Defined as the collaboration of science professionals and the public in science research, citizen science has tremendously improved the reach of science. With such reach, the research community has taken note by its extensive studies of one-half of citizen science participants, the public. This exploratory study expanded upon the research by investigating the specific tasks of the public and program coordinators (their roles), their perceptions, and participation outcomes. A socio-cultural theoretical framework was used in this investigation. Twelve participants responded to an online survey, and three interviews were conducted. The study found that participants assumed the roles of data collector (a very common role of participants), teacher-facilitator, and/or creator (an uncommon role). In sum, participants believed and partook in authentic practice while they engaged in this scientific endeavor.

CHAPTER 1: INTRODUCTION

Citizen science has emerged in recent years as an innovative and interactive tool for engaging many diverse groups in science and research (Rowe & Frewer, 2012). Imagine a father and daughter lounging in their backyard when they noticed birds feeding in nearby trees. They observed bright-feathered colors, distinctive sounds and songs, and different size birds perched in the tree. These observations by the public (typically called citizen scientists) are slowly becoming a mainstay of scientific research such that many researchers have challenged individuals to record similar sights and sounds on a daily basis. Great value has been derived from these records, and the scientific research community has taken notice. Unfortunately, no clear description exists that detail the roles, perceptions and outcomes of individuals participating in citizen science. Therefore this exploratory project seeks to alleviate this imbalance.

Many scientific organizations, community groups and individuals champion citizen science for the diversity of topics it tackles. The renowned Cornell Laboratory of Ornithology has led the charge with its extensive research on public participation in science, and investigations of birds. Project Budburst, an established citizen science program of the National Ecological Observation Network (NEON), focuses on engaging the public in collecting ecological data. The Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) engages citizen scientists in measuring precipitation across the United States (Cifelli et al., 2005). CoCoRaHS has even expanded beyond country lines to include Canadian observations. Academic programs from universities have also been designed to engage students in the methodologies and communication of citizen science (Brossard, Lewenstein, & Bonney, 2005).

The list of programs is extensive, and as one may imagine, participants serve a vital role in citizen science's progression.

The diversity of citizen science programs has been accompanied by an extensive collection of research data aimed at documenting the activities of participants and projects. There is documentation of data collection efforts, institutional impacts of citizen science, science literacy outcomes, environmental monitoring and activism, and attitudinal changes, just to name a few (Brossard, Lewenstein, & Bonney, 2005). However, gaps in the research and practice of citizen science still remain. For example, projects usually do not demonstrate how participation in citizen science activities beyond data collection may lead to some or all of the outcomes listed previously. Similarly, research has been limited by focusing on the outcomes of participants. Pay particular attention to the phrase, "to participants." Where outcomes have been documented, the research has been primarily directed at the public citizen scientists. Very little emphasis if any has been placed on the individuals coordinating citizen science participation, or on the specific roles of either participant.

Role acquisition in citizen science is an important area of research that this study seeks to detail. This exploratory study attempts to document the roles that both the public (citizen scientists) and *public engagement in science facilitators* (program staff) play in supporting and promoting citizen science endeavors. It explores the participation of these participants to clarify what they do, their thoughts about their roles, and whether participants' perceptions are actualized (or not) while engaging in citizen science activities. The importance of this exploratory project lies in insights that can be gained on how assuming these roles contribute towards participation outcomes, recruitment and retention of participants, and/or the process of

doing science. Fundamentally, this project provides greater understanding of what participants actually do or should do in citizen science.

To understand the roles of participants, the following research question was asked:

Research questions:

1. What roles do citizen scientists and public engagement in science facilitators play in the facilitation of citizen science activities?

Key Terms

Citizen science; *public engagement in science facilitators*; Participation Outcomes; Roles of Participants; Citizen Scientists

CHAPTER 2: REVIEW OF THE LITERATURE

Concerted efforts have emerged in recent years to engage the public in science, technology and policy (Chess & Purcell, 1999; Rowe & Frewer, 2012), and to connect them with science professionals (McCallie et al., 2009). Through these efforts, initiatives such as educational engagement, participatory democracy, public participation in scientific research, and institutional engagement have become staples of the Public Engagement in Science (PES) movement. Each initiative attempts to make science more accessible to all individuals by engaging them in the processes of doing, learning, or talking about science. It is worth exploring each initiative, but the central focus of this study is public participation in scientific research (commonly referred to as citizen science). Citizen science is a unique PES emphasis since engaging the public in science as its central premise incorporates many if not all of the other types of efforts to some degree. It pools participation of various stakeholders in scientific investigations (Trumbull et al., 2000) into an all-encompassing act where individuals or groups investigate science topics using different technologies while working with science professionals.

THE POPULARIZATION OF CITIZEN SCIENCE

Citizen science research collaborations between scientists and public volunteers is an increasingly popular venue for informal science education (McCallie et al., 2009). It has a long history of individuals making scientific observations and contributing to understandings about changing environmental conditions and the natural world. Most prominently, the fields of astronomy and ornithology have been instrumental in its creation and growth. As early as the 1740's, early records suggested that amateur volunteers monitored bird migration patterns across Europe (Greenwood, 2007). By the 1880s, the United States Geological Survey (USGS) engaged

the public in tracking the status and trends of North American bird populations. The 1900s even saw the National Audubon Society initiating the Christmas Bird Count as an alternative to the regular holiday bird-shooting contests of the day, which led to the popularity of ornithological monitoring in the United States (Dickinson et al., 2010). Ultimately though, it was the leadership of the Cornell Lab of Ornithology in both ornithological and citizen science research that has engaged over 200,000 citizen science participants and 5 million bird enthusiasts of all ages in bird monitoring (Cornell Lab of Ornithology, "*About Us*," http://www.birds.cornell.edu/page.aspx?pid=1609&ac=ac). The lab's leadership has fostered a vibrant present-day citizen science movement, supported significantly by the National Science Foundation's (NSF) Informal Science Education program (now called Advancing Informal Science Learning).

Many historical figures who have made significant contributions to science could be considered citizen scientists (e.g., Charles Darwin, Harold Mayfield, and Alexander Skutch). However, according to Lepczyk et al. (2009), the view that the public could actively participate and contribute to science faded over much of the 20th century when it was commonly felt that only professionally trained individuals could be scientists. Nevertheless, the increasing involvement of the non-scientific community in academic research, as Trumbull et al. (2000) so defined citizen science, has revived the importance of the public's participation in science and research in recent years.

Although astronomy and ornithology have the largest body of amateur experts and the longest history of engaging volunteers in professional research (Dickinson et al., 2010), citizen scientists regularly contribute data on many diverse issues. Working closely with citizen scientists, engagement facilitators supervise their activities, train new participants, and

implement data quality assurance measures. In many instances, facilitators are science professionals who use citizen science to complement their professional responsibilities, or are citizen scientists themselves. Lee et al. (2006) views this as citizen science that supplements and enhances conventional scientific studies (Eden 1996, Heiman 1997, Au et al. 2000, Pattengill-Semmens and Semmens 2003).

The greatest recognition of citizen science was sparked by the creation of the Center for the Advancement of Informal Science Education (CAISE) with support from the NSF in 2007. CAISE is a partnership among the Association of Science-Technology Centers (ASTC), Oregon State University (OSU), the University of Pittsburgh's Center for Learning in Out-of-School Environments (UPCLOSE), and the Visitor Studies Association (VSA). CAISE is housed at ASTC's Washington, D.C. offices. CAISE aims to coordinate informal science programs across disciplines and support their development and research (Price, 2011). CAISE established a citizen science inquiry group (Public Participation in Scientific Research [PPSR]) that focused on ways to use citizen science to increase public science participation. It also provided key recommendations to monitor its effects through rigorous research (Bonney et al., 2009). With publications such as "Surrounded by Science: Learning Science in Informal Environments" (National Research Council, 2009), there was a call for more citizen science projects. According to Price (2011), it then began to receive large-scale public recognition in mainstream science media circles, including articles in Nature magazine (Hand, 2010). In August 2012, in conjunction with the annual meeting of the Ecological Society of America, citizen science had its first major conference devoted to advancing the field by convening researchers and practitioners to present their latest research. I was one of the presenters discussing the perceptions of effectiveness in citizen science.

MODELS OF CITIZEN SCIENCE PROJECTS

Increasing recognition of citizen science has produced an outgrowth of citizen science projects. Each offers the scientific, research and education communities an important resource for carrying forth their endeavors (Conrad & Hilchey, 2010). Projects now represent a wide spectrum including investigations of climate change (CoCoRaHS, http://cocorahs.org/), ecology (Project Budburst, http://neoninc.org/budburst/), astronomy (Galaxy Zoo, http://www.galaxyzoo.org/), and water quality (Willamette Riverkeeper, www.willamette-riverkeeper.org/). Cross-disciplinary projects such as the Zooniverse's Old Weather project have also emerged where transcribing ship logs contribute towards improving climate model projections. Only a sample of projects is listed, but the wider range of projects demonstrates the diversity of issues projects investigate.

Projects fall in one or more CAISE models of citizen science depending on the levels of participation by volunteers. Only a few projects fit neatly into a particular model, which makes each model an idealized benchmark of participation (Brandt et al., 2010). The models are contributory, co-created and collaborative. A *contributory model* represents the stereotypical depiction that the layperson thinks of "citizen science." It uses mostly public citizen scientist participants as a distributed network of data collectors. Participants simply collect data and deposit them in a central repository (passive contribution). Imagine the father and daughter in the introduction again performing their observations. They collect their data and then upload them to an online database without any analysis or further consideration for the data they collected. However, should they be engaged in data collection and/or data processing, they would fall into the active contribution model (Brossard, et al, 2005; Evans, Abrams, Reitsma, Rouxt, Salmonsen, et al., 2005; Wee & Subaraj, 2009).

The second CAISE model is the *collaborative model*. Citizen scientists in these types of programs may join public engagement in science facilitators in having greater ownership of the engagement experience. They collect data in addition to developing explanations or helping to analyze data. A popular example of a collaborative model is the Galaxy Zoo project. It is an online project where participants, over 150,000 people strong and counting, make multiple independent classifications of objects from different galaxies. Galaxy Zoo even reported receiving almost "70,000 classifications an hour" within 24 hours of launching its site (Galaxy Zoo, "The story so far")!

The third and final CAISE model is the *co-created model*. Participants have the greatest ownership of participation in a citizen science project through this model. They are involved in every phase of a project from design to execution and communication of results. That is, participants help to develop research questions, collect data, provide explanations, publish results, and everything in between (Bonney et al., 2009). This more demanding model is sometimes called *participatory* action research (Cornwall & Jewkes, 1995; Ballard, 2010). Only a relatively few active projects, however, exist that use this third model (Bonney, et al. 2009). Shermans Creek Conservation Association, and Citizen Sky use examples of a co-created model.

ROLES OF PARTICIPANTS IN CITIZEN SCIENCE

As the number and types of projects have increased, so too have the reasons for embracing public participation in citizen science projects (Poliakoff & Webb, 2007). A common theme observed among the reasons is the incorporation of multiple actors and agencies in scientific discourse (Reed, 2008). This study directs its focus on this common theme regardless of which model of program they participate in.

Given the focus on engaging the public in science, and the affordances of citizen science projects, it is surprising that few studies have explicitly investigated the roles participants in citizen science take on. Rather, greater emphasis has been placed on the outcomes of participation (Carolan, 2006; Robertson and Hull, 2001; Carr, 2004; Cooper et al., 2007; Schwartz, 2006; Sultana and Abeyasekera, 2008; Whitelaw *et al.*, 2003), or the challenges of data collection and data use (Gouveia *et al.*, 2004; Kershaw and Cranswick, 2003; de Solla *et al.*, 2005; Dickinson et al., 2010). Where literature exists, broad descriptors defining participants' roles are usually brought to the forefront. At present, Cooper et al. (2007) provided the best description of the roles in citizen science when he compared the different community science research models that involved the public in significant ways. An Adaptive Citizen Science Research Model (see Appendix A) was proposed as a framework for participants to collect data on ecosystem elements (e.g., bird populations). No study has explicitly stated what participants should be doing. Instead all agree that they collect data, and they may or may or perform other tasks.

CHAPTER 3: THEORETICAL FRAMEWORK

A socio-cultural theoretical framework is a useful perspective for understanding the shared experiences of individuals in citizen science. Socio-culturalism is based on conceptions embedded within and constituted by a network of social relationships and interaction within a culture (Vygotsky 1962, 1978; Wertsch 1991). It offers another analytical lens to focus in on understanding the collaboration of participants in citizen science who strive to understand each other's needs and work together to promote a shared goal (Tomasello, et al., 2005; Stryker, 1980). This shared goal is the collaboration that addresses various environmental and related issues. Note that the degree of collaboration varies with the model of citizen science in use as described earlier (Bonney et al., 2009).

Citizen science socio-interactional patterns are intricately linked to the actions that individuals perform (Wertsch 1991), and the roles they assume. These roles are rooted in cognitive apprenticeships that enculturate individuals in authentic practices through activity and social interactions, similar to craft apprenticeship (Brown, Collin & Duguid, 1989). Such social interaction and construction advance learning. As citizen scientists and engagement facilitators participate in citizen science activities, participation is distributed through a complex process involving the mind, body, activity, and culturally organized settings involving other actors (Lave, 1988, p. 1). Participation thus is framed around conceptions of the self in social endeavors where learning from, and with, others is present.

Participation in shared activities through social interactions with others results in knowledge or conceptions of the self. Knowledge or conception of the self is one's identity (Vygotsky 1962, 1978). Packer & Goicoechea (2000) viewed the socio-cultural conception of identity as addressed in the fluid nature of human beings linked to participation and learning in a

community. Specific to this study, a socio-cultural theoretical framework offered a unique perspective for interpreting the fluid nature of participation, as well as the fluidity through which individuals identify with their roles while engaged in citizen science activities.

CHAPTER 4: METHODS

STUDY DESIGN

This study was an exploration into the social relationships and interactions of individuals who participated in citizen science activities. In this design process, investigations of phenomena little understood are conducted (Creswell, 2007). The phenomenon I tried to document are the roles that citizen scientists and public engagement in science facilitators take on from participation in these activities. It also documents the fluidity of roles among the research participants through their interactions within the citizen science community of practice. Essentially, the exploration attempted to understand the identities research participants developed through the activities they performed.

The sample in this study included the general public, often characterized as citizen scientists, and "public engagement in science facilitators." The latter is a term I fashioned to denote the persons coordinating, supervising and/or facilitating the occurrence of citizen science. They also are the persons responsible for fostering a network of volunteers to promote their programs' goals. Survey data was collected from these individuals. Interviews were also conducted to expand upon and clarify the data obtained from the surveys.

The study was conducted between April and October 2012. An extensive online search was conducted from which approximately twenty-eight citizen science programs were selected and contacted. The programs represented large-, medium-, and small-scale citizen science programs or projects that performed science-related investigations with the assistance of the public. A shorter list of programs focusing on atmospheric or environmental issues was originally selected and contacted, but yielded only 2 responses. The search criterion was expanded to include all citizen science programs/projects.

A solicitation for participation was directed at the public engagement in science facilitators. The solicitation included an invitation for citizen scientists, who took part or had taken part in their citizen science programs, to participate in this study. It was through these gatekeepers that I hoped to gain the confidence of research participants, and tried to understand their roles in citizen science programs (Creswell, 2007, p. 120). All research participants were asked to complete an 18-item online survey, which included open-ended and Likert-type scale questions (See Appendix B). All individuals responding were requested to participate in a follow-up interview. No research participants agreed to be interviewed so two citizen science experts (researchers and practitioners) were interviewed in order to learn about the diversity of roles emerging from participation.

PARTICIPANTS

A "big net" approach to sampling as recommended by Fetterman (1998, p. 32) directed my selection of study participants (*cf.* Creswell, 2007, p. 128). The approach suggested interacting with many individuals in the citizen science programs then selecting individuals who could highlight what is typical activity in these programs. I was specifically interested in a typical role participants assume or assumed in the programs in which they engaged. As such, only the public engagement in science facilitators received a direct invitation from me. The citizen scientists were invited to participate in this study via invitations from the public engagement in science facilitators. All participants were over the age of 18 years.

DATA COLLECTION

Methods for data collection included an online survey for all participants, and telephone interviews with two expert engagement facilitators. Emails containing information about the

study and soliciting participation were sent to 28 citizen science programs. Twelve people completed the survey administered through Survey Monkey (www.surveymonkey.com). They could complete the survey in one sitting or multiple sittings.

To expand upon the roles identified in the online survey, my research design had included an interview component. Since no survey takers volunteered to be interviewed, two engagement facilitators were interviewed. These engagement facilitators expanded my ability to analyze and interpret the data by evaluating the data collected. The interviewed facilitators were program staff, practitioners, and/or citizen science researchers. These interviews lasted 20 – 25 minutes, and were conducted in a conversation-like manner. Those interviewed received a pre-analysis of the survey data to guide the conversation.

DATA ANALYSIS

Methods for data analysis followed principles of phenomenological research. Phenomenological research describes the meaning for several individuals of their lived experiences around a concept or phenomenon (Creswell, 2007). It further describes what participants have in common as they participate in shared experiences; in this study, for a description of citizen science activities. Data analysis thus results in an examination of the data for significant statements, sentences and/or quotes that provided an understanding of how participants experienced their roles. This step is called horizonalization (Moustakas, 1994).

Themes were developed from the significant statements of the survey data that detailed the roles, perceptions and outcomes of participation. Clusters of meanings were extracted from these themes. A textual description of what participants experienced was then produced. The description provided an overview of the "essence" of participation that was used as the basis for evaluating citizen science participation. The citizen science experts provided this evaluation.

CHAPTER 5: RESULTS

CITIZEN SCIENCE PARTICIPANT INFORMATION

Survey Data. Information about the types of research participants (n = 12) in this study is presented in Table 1. Seven reported that they were citizen scientists currently or had participated in the past. Eight were public engagement in science facilitators, and one defined him/herself as "other." It should be noted that participants were permitted to state multiple roles that they assumed in their current or past participation in citizen science projects.

Types of research participants	Number of research participants*
Citizen scientists	7
Public engagement in science facilitator	8
Other	1

Table 1 lists the types of respondents and the amount of respondents assuming those types. *A total of 12 individuals responded to the survey.

Most of the research participants were females aged 56-70 years (n=5). Others were between the ages of 26-35 years or older than 70 years (n=2). Approximately half did not provide this information. No one responded to the survey that was under 25 years or between 36 and 55 years.

All were of European descent and held an advance degree (n=6). Including those that had some college experience, study participants held a Bachelor, Master, Doctoral or a professional degree (n=7). No one participated in the study that did not have some college experience. Of those that provided information on their professional roles (n=8), they fell into one of three professional categories. They were a director, administrator or manager (2 people); a researcher, scientist, or engineer (2 people); or an educator, teacher, instructor or faculty (2 people). The remaining 2 others were "retire[d]" or "worked in program management but was not [a] manager."

PERCEPTION OF PARTICIPANTS IN CITIZEN SCIENCE

This study attempted to create a generalized account of citizen science participants' activities and their perceptions of the roles they assumed and the outcomes of their participation. Unfortunately, despite numerous reminder emails, the response rate was extremely low so the sample size is small. Thus the results presented here only offer a glimpse into participants' activities, and a snapshot of the citizen science field.

To try to understand the perceptions of participants in citizen science, the questionnaire asked about their attitudes and motivations for their roles in current or past projects. Seven people responded to this item. On a five-point scale, four strongly agreed that it was extremely important for participants in a citizen science program to be highly motivated, responsible and/or interested for the program or project to succeed. Two somewhat agreed with the statement while one strongly disagreed. Four people further added that they had moderately high motivation to participate in their programs' citizen science activities. Three reported very high motivation to perform their citizen science activities.

Six people described the role that motivation played in influencing their decisions to participate in citizen science programs. Research participants were motivated to provide reliable, quality data if data collection was the objective. If data collector was the role assumed, one person added the need to follow through on his or her commitment as a volunteer. Another stated:

> "One must show up to do the work if the project requires labor"

Another person highlighted the demand of sustaining one's efforts throughout participation. S/he believed starting a citizen science program was not sufficient enough to

influence participation, and the roles s/he assumed, but also persevering and remaining consistent in reporting results was important. The following statement illustrates this perception:

> "I had to be sufficiently motivated to follow through not just starting the program, but sticking with it and consistently reporting results"

Participating in citizen science activities was recognized to emerge from a natural interest in the subject of investigation, but with the caveat that it may or may not be participants' main priority. One person viewed citizen science as a hobby for volunteers in contrast to the public participation in science facilitators who may actually be paid staff stating: "There has to be a natural interest but it's not realistic to assume it will become anyone's number one priority in life. Citizen science is a hobby for everyone, but program employees." In fact one person's motivation to participate was because it was his or her professional responsibility.

OUTCOMES OF PARTICIPATION IN CITIZEN SCIENCE

Reasons for participation

People in the study participated in citizen science for a number of reasons and sometimes their roles changed over time. For example, one person reported that participation in a citizen science program initially served to fulfill a prior commitment or obligation. S/he stated I was active in a project "initially to fulfill [a] requirement for [a] BS degree in Ecology." S/he was "then hired as a seasonal field technician and assistant to [the] project coordinator in the program."

Others' participation served to facilitate their personal science education goals. The following statements exemplified some of the science education goals research participants recalled:

"It is a great mix of science, education and working with invested and excited people"

"My interest in CS stems from my lifelong work as a science educator. CS provides an intriguing approach to advancing STEM education and environmental science"

"I was a career science teacher. I was always looking for current research for myself and students. During the past decade, Texas initiated a Master Naturalist program which complimented what I was doing"

"Aid in broad scale science initiatives"

"I am the program manager for a citizen scientist volunteer program. I enjoy working with science education for the adult demographic"

Two people participated in citizen science as the creator of the citizen science project. Unfortunately, they did not specify in detail the reasons why they created the projects, but they acknowledged their roles as creators:

"I started the program."

"I created and coordinate[d] a citizen science program."

Others participated in projects to aid data collection efforts and/or to perform worthwhile tasks. Some of the reasons that emerged included:

"To do something other than read[ing] and hear[ing] about the problems [and] to actively work with eradication seems very worthwhile to me" "inadequate funding by governmental agencies to provide staff to do the work and to "learn more about the environment."

"To build "awareness of the topic/species being studied (i.e. birds, rainfall, amphibians), and a desire to help add to conservation information / database."

Outcomes of participation

Only 7 participants reported the outcomes of their participation in citizen science programs. All seven reported that participation in citizen science resulted in data collection. Research participants characterized this outcome as:

> [Collecting] "valuable data."
>
> [My] "contribution as a volunteer provided competent research data at no or little cost to that project."
>
> [I learned] "more detail about the particular studies while helping provide data to trained scientists conduct their work."

Various education outcomes also emerged from participation in citizen science programs. For example, one person reported an "increased appreciation and respect for online learning." Another person indicated an outcome was "education" in general. And a third person expressed his/her participation outcome as "engagement with many volunteers."

The third major outcome of participation related to the self. One research participant reported receiving "enjoyment of getting out and watching birds, feeling like I'm making a positive contribution." Another received "satisfaction, participation, education, and [participating in] worthwhile efforts joined by others." One other research participant took or is taking away "an increased awareness of the species abundance in our area."

ROLES OF PARTICIPANTS IN CITIZEN SCIENCE

Over half of the study participants reported no role change (n = 6 of 10) after they joined their citizen science project(s). Four of ten people who provided this information indicated that their roles did change.

Length of participation in the programs varied. One out of the 12 people participated between 0 – 2 years in the program(s), four participated between 3 – 5 years, three participated for 6 – 8 years, one person for 9 – 10 years, and two people participated for more than 10 years. One person did not provide this information.

When asked to describe the activities participants performed in their current or past project, one person reported that he or she performed "monitoring, data compilation and analysis, [and] communication with volunteers." Another participant "collect[ed] plankton at three different sites for NOAA's hazardous phytoplankton program." Two more participants reported, respectively: "Invasive species monitoring, compost training and awareness demos for public," and "helping identify invasive species; took part in a survey to determine the presence of a particular species of moth; [and] aquatic animal count."

Another person listed examples of projects in which he or she participated showing his/her commitment to citizen science efforts:: "Project Feeder Watch (counting birds at feeders in my yard during winter), Great Backyard Bird Count (bird survey over one weekend in February), Christmas Bird Count (similar); [and] Community Collaborative Rain and Hail, Snow (CoCoRaHS) [where we] report[ed] precipitation in our yard."

Research participants also reported other tasks they performed during their current or past participation. One participant stated that he or she took part in speaking programs, sponsored policy to replace invasive species in the water district where he or she worked, and worked with individuals to identify invasive species. The director of a major citizen science project reportedly did program management, outreach, resource development, and budget oversight.

Interviews. Three citizen science experts agreed to be interviewed to discuss the data and findings from this study. Ultimately though I was only able to conduct two telephones

interviews. One of those interviewed by phone (a citizen science researcher at a major university and citizen science center) agreed that given the sample size, the results presented in this study were not generalizable, but rather the study was exploratory. S/he believed the study was "novel for tackling this subject." The other person I interviewed (a citizen science coordinator and researcher) thought that the low response rate might have resulted from survey saturation or fatigue, defined as a decline in survey response rates due to repeated surveying of the same person or persons (Porter, 2005). This person thought that this could have resulted from programs and researchers constantly evaluating their work to make improvements to programs, or to document outcomes of citizen science.

The other person I interviewed by phone believed that although exploratory, the data aligned well with findings in the literature and his/her personal observations over a long career. For example, people in the study had participated in citizen science for a number of reasons including fulfilling a requirement or obligation, facilitating science education goals, aiding data collection efforts, contributing to a meaningful endeavor, and even creating programs. S/he thought it was quite interesting for a participant in citizen science to do so to fulfill a class requirement outside of the setting and thought that this finding might be unique to the person who provided it though it seems like a great way to increase the age diversity of participants. It might also provide entry points for communities underrepresented in STEM.

CHAPTER 5: DISCUSSION AND CONCLUSION

This study aimed to explore the roles of participants in citizen science projects through examination of their social interactions and activities. Fundamentally, I wanted to document what citizen scientists and public engagement in science facilitators did in the performance of citizen science activities. The study also sought to describe what participants thought about their participation, and the outcomes resulting from their activities. An online survey was conducted that provided valuable data that was both quantitatively and qualitatively analyzed. Though a very small sample, the data provides some interesting glimpses into participation-related roles and outcomes.

An evaluation of the study data revealed that data collection was a reason for participation in citizen science projects, and the primary outcome of citizen science participation. This role represented the stereotypical depiction of laypersons in citizen science activities. Data collection as a major task fell into the *contributory model* where participants are used mainly as a distributed network of data collectors (Brandt et al., 2010). Interestingly, this is not surprising as the vast majority of projects charge participants with the collection of environmental information, and its submission to data centers. Exceptions to this, however, exists where citizen scientists may be asked to transcribe already collected information (Old Weather, www.oldweather.org)

Research participants also engaged in citizen science to facilitate specific science education goals. For example, one person viewed citizen science as beneficial for teachers and students in the classroom. Further, certification in another volunteer program (e.g. Master Naturalist program) complimented this teacher's actions. Another enjoyed working in science education for adults. These examples of education goals align with outcomes documented in

other research studies. This study documented that participants had an appreciation for online learning, and that they performed various educational activities during participation. For example, outreach, speaking engagements, and conducting awareness demonstrations for the public were performed. Significantly, each activity occurred for, or on behalf of others who likely benefitted from their participation in citizen science. These participants can be regarded as sharing an identity of educators or "teacher-facilitator."

One of the experts I interviewed believed participants possessing an educator role had a "very sophisticated identification with that role." She continued, "If you learned something, you should be able to teach it to someone else. This falls high on Bloom's taxonomy of thinking." The other expert added, "In some projects, coordinators [public engagement in science facilitators] do everything." An educator role represented the next level of participation beyond simply data collection. This role aligned with a co-created model of citizen science participation where participants do more than data collection. They are the voices working to get the word out to other participants, as well as the role models that attract potential participants to citizen science (Clarke, 2011).

A smaller number reported themselves as creators of programs. Both experts estimated that the percentage of people assuming these roles would be extremely low, regardless of the size and scope of a program. Only two creators participated in this study. This finding is consistent with the "funnel-shaped" structure of citizen science programs. That is, programs typically consist of a small staff of science professionals, and a large pool of volunteers. There are tens of thousands or perhaps millions of citizen scientists in contrast to the hundreds or perhaps thousands of citizen science programs. Consequently, only a selected few individuals ever become program creators.

Overall, this study showed that participants assumed the roles of data collectors, teacher-facilitators and in a few cases, creators. The role of data collector is the characteristic role of individuals who participate in citizen science activities. The latter two were interesting examples of volunteers who had greater ownership of their experiences. The roles participants assumed seemed to also be constrained by the program they participated in. One expert interviewed noted that a typical role was dependent on the types of programs volunteers participated in and the affordances they offered. Some programs only needed the help of data collectors, while others sought greater participant input. Although a small sample it seems that it the design of citizen science programs that shaped the roles assumed by participants, rather than the desires or beliefs of participants.

ROLES, CITIZEN SCIENCE PARTICIPATION AND SOCIO-CULTURALISM

A socio-cultural framework was essential to the research in this study and even shaped who I tried to include as research participants. For example inviting both citizen scientists *and* engagement facilitators was an effort to offer a balanced and fuller perspective of citizen science participants and fills a gap in the research regarding the impact of these programs on the scientists, educators and staff coordinating them, also participants. To understand the perceptions of participants, consideration of their motivation and attitudes in the shared endeavor is critical. Unfortunately, for the most part, the survey instrument did not adequately tease this out, possibly because it is difficult to gather this kind of information with a questionnaire, which is why I had included interviews. My original design even included observations of participants' roles in practice, which were not possible given the time and scope of a Master's project.

Although it is impossible to make any generalizations with such a small dataset, what I can discuss are some interesting qualitative findings that emerged from open-ended items. They offer insights into why a socio-cultural framework is essential when studying public engagement efforts like this. They highlight the shared nature and goals of participation in these programs, the importance of the social relationships and interactions between participants, and the role that engagement in authentic practices with "real" scientists play in supporting public understanding of the science enterprise.

As this study illustrated, some study participants assumed new roles from their participation in citizen science projects. Others did not change their roles. Instances emerged in which participants used their experiences to become better teachers, and/or used citizen science as a resource for their students. There was also evidence that a few participating in multiple projects at one time. These findings demonstrate what Lave and Wenger (1991) have come to call legitimate peripheral participation in a community of practice in which citizen science is one example of a community of practice. Lave and Wenger suggested that learning is achieved within communities of practice as a result of participants' increasing participation in legitimate, although initially, peripheral activities. Typically legitimate peripheral participation in citizen science is evidenced by a person becoming a dependable, reliable data collector, without becoming a core member of the citizen science team. Examples of this are participation in multiple projects at one time, or remaining a data collector after months or perhaps years in a project.

Legitimate peripheral participation is also envisioned as local events of engagement in certain activities with certain knowledgeable people (Wenger (1999, p. 4). Such engagement is reflected in sharing the *practices* of social communities and constructing *identities* in relationship

to these communities. Though a small study, this engagement was clearly evident among study participants. For example, citizen scientists responded to the requests of engagement facilitators to collect environmental information to share with various third parties (e.g. National Weather Service). The Sherman Creek Conservation Association, a co-creative project, even went further to make volunteers knowledgeable team members invested in conservation efforts for the betterment of local communities.

The citizen science community of practice is unique in itself given the number of individuals it brings together for a common/shared purpose of engaging in science. Most profoundly, scientists are engaging with the public in worthwhile endeavors, science and education often through social media, websites, and community forums. However, and as depicted here, a vast majority of participants are white from middle-class backgrounds. It seems like it could be an interesting way to bring together different races, ethnicities, socio-economic classes, and types of professionals. However, much is still needed to further understand how to diversify the demographics of participants, as well as understand their role in the scientific conversation emerging from citizen science activities.

Indications have emerged from this study that programs are making people more aware of the science around them. For example, study participants were aware of the dangers of invasive species on local habitats. Others were aware of engaging "adult demographics" in online learning. And a few either wanted to enjoy the outdoors or learn about the environment. These indications demonstrated citizen science participants had some conception of their roles in their communities or responsibility for the environment. This finding points to the importance of citizen science in influencing participants' perception of their sense of self within the environment, and among their neighbors. Sense of self was socially defined as well as

contextually shaped, both of which are important for determining the social relationships and interactions participants may have with others.

Finally, this study provided some indications of how citizen science participation resulted in engagement in science and a feeling of contributing to the science endeavor. One participant reported, "to do something other than read[ing] and hear[ing] about the problems [and] to actively work with eradication seems very worthwhile to me." Other participants also talked about their contribution to science, evident in their concern about quality data collection efforts. It also seemed that some citizen scientists may become proactive members of society in the area of the environment.

CHAPTER 6: IMPLICATIONS

Given the extremely low response rate and the insights gleaned from this study, a re-conception of this study would provide a richer understanding of the relationships and interactions occurring in citizen science. This re-conception would explore how participants' relationships and interactions provide meaning to their experiences in the course of performing citizen science activities. That is, how did the meaning attributed to the roles they assumed shape or influence their thoughts about those roles? This study found that participants were motivated and interested in their activities, but the research instrument was inadequate in soliciting more information on the social dimensions of their motivation or even how participants interpreted their roles while working with others.

Promising data was collected about the diversity of citizen science participants' occupations, but a focused investigation is needed to tackle the larger issue of racial/ethnic and socioeconomic diversity in citizen science. Citizen science programs encourage everyone to participate in their activities. However, most participants are white, older, middle-class. Why is this the case? Furthermore, the engagement facilitators engaging public volunteers are also typically white and middle-class. As a next step, I would like to investigate the features of citizen science that seem to inhibit participation, or how to encourage the wider population to assume available roles in citizen science. I challenge the field to consider what about the social relationships and interactions in citizen science do not encourage participation by a wider group of citizens. Maybe it's the language of science used, or the exclusivity of individuals who lead and participate in these programs.

CHAPTER 7: ACKNOWLEDGEMENT

I want to acknowledge those who helped me with this project along the way and into its' completion. First, special thanks goes to my advisor at Oregon State University professor, Dr. Lynn D. Dierking, who has been a strong supporter. I am especially thankful to Dr. Jennifer Bachman and Dr. Christoph Thomas for their willingness to serve on my committee, and guide me onto the next phase of my life. I want to thank experts at the Cornell Laboratory of Ornithology, and the National Ecological Observation Network, for evaluating my survey data. There is also unbound grateful to my survey respondents who to the time to provide this data I was able to work with. Finally, I want to acknowledge all of the professors and fellow students that have taught and interacted with me in the different courses I have taken during this an ever-learning experience.

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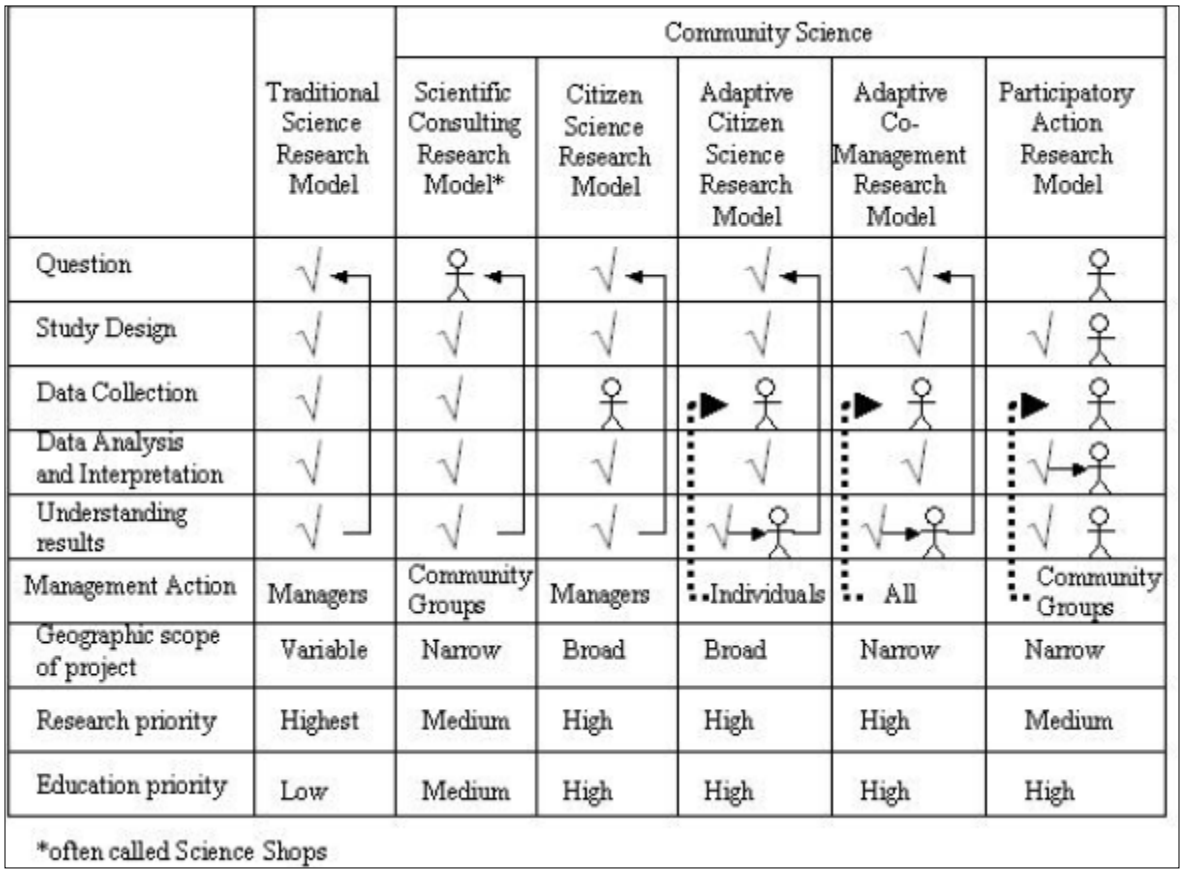
Appendix A. Types of Citizen Science Participation

Figure 1. Different ways that scientific inquiry can inform the adaptive management of natural resources, with the scale of management, as well as optimizing the dual goals of research and education, maximized in the Citizen Science and Adaptive Citizen Science models. Check marks indicate professionals; stick people represent public participants. Dashed arrows indicate the iterative aspect of the adaptive management process and solid arrows indicate the iterative aspect of the scientific process. Small arrows between professionals and public participants indicate points of intensive transfer of information, an important element to ensure "buy-in" of participants in taking action. The degree of collaboration between professionals and non-professionals increases from left to right



Source: Cooper et al. (2007). See reference list

Appendix B. A Copy of Survey Instrument

Participation in Citizen Science Programs

1. In what capacity have you participated in a citizen science program? (*Choose all that apply*)

    0. Citizen scientist
    1. Public engagement in science facilitator (Scientists, program field managers, instructional material designers, web site developers, community citizen science coordinators, program consultant, resource and the like)
    2. Other *(please specify)*

2. Did your role change after joining the program?

    1. Yes
    2. No
    0. Decline to respond

    If yes, please explain

3. How long (*in years*) have you been participating in this or other citizen science program(s)? (*Choose one)*

    1. 0 – 2 2. 3 – 5 3. 6 – 8
    1. 9 – 10 5. More than 10 years

4. Briefly describe your reasons for participating in this program

5. What were you expecting to get from your participation in the program?

Outcomes from Participation in Citizen Science Program

6. Briefly describe the citizen science tasks or activities that you performed in 2011. *If no tasks were performed, state the tasks performed the last time you participated.* .

7. What do you think you took or are taking away from participating in this/these program(s)?

8. Are these the outcomes you expected?

    1. Yes
    2. No
    0. Decline to respond

    If yes or not, please explain

Attitudes towards Participation in Citizen Science Program

9. **Please rate the extent to which you agree or disagree with this statement: "**It is extremely important for participants in a citizen science program to be highly motivated, responsible and/or interested for the program to succeed?"

    1 Strongly disagree
    2 Somewhat disagree
    3 Neither agree nor disagree
    4 Somewhat agree
    5 Strongly agree
    0 Don't know

10. How motivated are/were you to participate in this program's citizen science activities?

    1. Very high
    2. Moderately high
    3. High
    4. Moderately low
    5. Low
    6. Very low
    0. Decline to respond

11. Please describe the role that motivation plays or played in influencing your decision to participate in the citizen science program?

12. Has your attitude towards participation changed over time?

    1. Yes
    2. No
    0. Decline to respond

    If yes/no, please explain how.

Demographic Information

13. What is your gender? (*Choose one)*

    1. Male
    2. Female
    3. Other
    0. Decline to respond

14. In which age bracket do you belong? *(Choose one)*

    1 . 18-25
    2 . 26-35
    3 . 36-45
    4. 46-55
    5. 56-70
    6. Older than 70
    0. Decline to respond

15. Please identify your ethnicity or cultural heritage. Do you consider yourself as...? *(Choose all that apply)*

    1. African
    2. African American
    3. East Asian (including Asian/Pacific Islander and/or Asian)
    4. European
    5. Indian Subcontinent
    6. Native American
    7. Native Alaskan
    8. Middle Eastern
    9. Non-Spanish-speaking Caribbean (including Haiti, Barbados, West Indian, etc.)
    10. Latin American (including Spanish–speaking countries of the Americans and Brazil)
    11. Pacific Islands (including Pacific-Islander and specific Pacific Island nationalities, including Filipino)
    12. Other *(please specify)*
    0. Decline to respond

16. What is the highest level of education you have completed? (*Choose one)*

1 Some high school
2 High school graduate/GED
3 Some college
4 Bachelor's degree
5 Master's degree
6 Doctoral or professional degree
7 Other (*please describe)*

17. What is your main job/primary professional role? (*Choose one*)

1. Director/Administrator/Manager
2. Researcher/Scientist/Engineer
3. Educator/Teacher/Instructor/Faculty
4. Technician
5. Student
6. clerical
7. Other *(please specify)*

18. Please state any other jobs/professional roles you currently have.

Thank you for completing this survey.

Before you exit the survey, we would like to invite you to participate in a follow-up interview. The interview aims to explore further your responses to this survey. Your participation is optional, and requires 10 - 15 minutes to complete.

If you would like to participate in this phase of the study, please indicate below by selecting "Yes, I want to participate in follow-up interview." Provide a contact telephone number or e-mail address in the box. Only the researchers will have access to this information, and your personal contact information will be deleted from our records after the interview.

Otherwise, select "No, I DO NOT want to participate in follow-up interview."

Yes, I want to participate in follow-up interview
No, I DO NOT want to participate in follow-up interview

If yes, please provide your contact information:
_____

Interviews may be audio-recorded as part of the data collection process. However, this is optional. Please indicate your consent to the audio-recording of your interview by initially one of the two statements:

_____I agree to be audio recorded.
Initials

_____I do not agree to be audio recorded.
Initials