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Citizen Science: Framing the Public, Information Exchange, and Communication in Crowdsourced Science

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I am submitting herewith a dissertation written by Todd Ernest Suomela entitled "Citizen Science: Framing the Public, Information Exchange, and Communication in Crowdsourced Science." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Communication and Information.

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Citizen Science: Framing the Public, Information Exchange, and Communication in Crowdsourced Science

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For my mother, my aunt and my dad. Two who are still here and one who is missed.

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Abstract

Citizen science, the participation of non-scientists in scientific research, has grown over the last 20 years. The current study explores the communication frames used to describe citizen science and how they are created. It also investigates the effects of citizen science on the relationship between the public and science. It also situates citizen science in a larger historical context that critques normal science and intersects with a number of other scholarly discussions including science and technology studies, citizenship, expertise, professionalism, and participation.

The dissertation draws on theory from the social worlds analysis of Anselm Strauss, framing in science communication, the philosophy of John Dewey on inquiry and the public, and the communicative action theory of Jurgen Habermas. It uses these theorists to build a potential analysis of the social impact of citizen science and the effects on science-public interaction.

The study examined 166 news articles, 13 press releases, and 10 interviews collected between July 2013 and April 2014. Situational analysis was used to analyze the material and to map the social arena of citizen science.

The results show that current communication frames used to study science communication do not adequetely reflect the frames used with regard to citizen science. The most common frame promoted by researchers and staff involved with citizen science projects is educational. It also describes the tension within citizen science between emancipatory-participative and instrumental-pragmatic goals.

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Chapter 1

Introduction

Citizen science is a term used to describe the recruitment of non-scientists to assist scientists with research. The term was introduced in the 1990s and has become much more widespread over the past decade. The development of the Internet opened up new opportunities for scientists to work directly with volunteers in order to collect and analyze data from a variety of scientific disciplines. At the same time there have been changes in the social relations between science and the public which have made it possible for the contributions of the public to be incorporated into technoscientific questions. These two trends, technological improvement of networks and growing concern with the public understanding of science, led to the current interest in citizen science.

Some studies have already investigated the educational impact of citizen science and the motivations of volunteers (Bonney et al., 2009; Brossard, Lewenstein, & Bonney, 2005; Trumbull, Bonney, Bascom, & Cabral, 2000). Another stream

of scholarship has looked at the validity of the data collected by citizen science volunteers (Crall et al., 2011, 2010). Efforts to classify the different types of citizen science projects have also been completed (Wiggins & Crowston, 2011, 2012). This dissertation fills a gap in the study of citizen science by looking at the framing of citizen science within the media and the potential impact of that framing on the relationship between the public and science.

The first chapter is a literature review of the research on citizen science focusing on the efforts to taxonomize projects, deal with educational outcomes, and discuss validity of volunteer data. It also addresses some of the historical roots of amateur participation in science and the development of crowdsourcing, a recent term to describe the participation of large groups in collective projects.

The second chapter deals with a number of sensitizing concepts which are needed in order to understand the context in which citizen science developed. Science, public, citizenship, expert-novice, professional-amateur, and participation are the concepts described in this chapter.

The third chapter focuses on two theoretical topics. The first is the description of the theoretical background for the evidence analyzed in this dissertation. Two areas provide guidance - social worlds and communication framing - for the development of items to be measured. The second topic is critical in nature and attempts to use the work of John Dewey and Jurgen Habermas to develop the concept of the public, inquiry, and communicative action which may all be applied fruitfully to citizen science.

The fourth chapter describes the methods used for the current study. Four primary types of data were collected: bibliographic, observational, media content, and interviews. The material was analyzed using situational analysis, a qualitative method drawing on the background of grounded theory.

The fifth chapter describes the results found through the analysis of the four types of data. It follows the outline of the research questions starting with the framing of citizen science and the creation of frames. Next it describes some of the emergent development of themes based on the sensitizing concepts introduced earlier. It concludes by looking at evidence for a changing relationship between science and the public as a result of citizen science.

The sixth chapter discusses the findings of this dissertation. The first topic discussed are the two different paradigms of citizen science research prevalent in literature and interview data. The first paradigm is the emancipatory-participative which has significant roots in science and technology studies and risk studies. The second paradigm is the instrumental-pragmatic which has roots in observational sciences such as ornithology and the growth of sensor networks across the world. The chapter continues with a discussion of boundary crossing between science and the media as well as a discussion of different mediators who help to manage this boundary. The final parts of the chapter use some of the social theory described earlier in order to begin a critical examination of how citizen science may effect the relationship between science and the public.

The study of citizen science is important because the modern world is dependent upon science and technology in a myraid of ways. Economically technoscience has transformed the world over the past 300 years from the early days of the Industrial Revolution to the current development of the Internet and World Wide Web. Technology and science have also transformed the social structure of the world by altering the means of communication, economic exchange, and group formation. One consequence of these changes has been the increasing dependence of the public upon expert judgment. No single person can understand the complex systems of technology which have been built up around us over the past few centuries, instead we trust the knowledge of others and depend upon them to build systems that are safe and reliable (Giddens, 1990). We are surprised and often unprepared for when these technologies break down (Bowker & Star, 1999).

The relationship between the public and science has altered over time. During some epochs the public lets scientists have a free reign to pursue inquiries as they see fit. At other times there is much tighter control over and criticism of scientific behavior and research. The history of public-science interactions in the United States can be divided into two periods since World War Two. The first period saw the ascendence of science as an autonomous activity, supported by government, but free to pursue any research. During the second period the public began to question the right of scientists to regulate their own research interests. Some research topics, such as nuclear power and stem cells, raised complicated moral problems which science seemed unable to

address by itself. Other problems including the environmental crisis led to spreading distrust of the scientific establishment (Lengwiler, 2008; Lewenstein, 1992).

The response among scientists and the researchers who study science has been to look more closely at the relationship between the public and science. Calls for increasing the public understanding of science were abundant during the 1980s (Gregory & Miller, 1998). But communication scholars pushed back, saying that scientists cannot expect the public to just acquiesce to their pronouncements about facts. The perception of facts are shaped by emotions and language (Brossard & Lewenstein, 2009; Nisbet, 2009).

Science is still respected among the public but the recognition of the need for public input is growing. Scientists were never completely autonomous from society; they have always been dependent upon the social and economic fabric which surrounds them (Douglas, 2003). A variety of methods have been proposed for increasing the public participation in scientific research have been proposed over the past 30 years including citizen juries, negotiated rulemaking, study circles, social audits, and many more (Rowe & Frewer, 2005). Citizen science is one example of how the public can be included in the scientific process.

1.1 Literature Review

1.1.1 Definitions

The earliest use of the term ‘citizen science’ was by the sociologist Alan Irwin in his 1995 book of the same title. About the title he writes:

> . . . I chose it because it conveys both senses of the relationship between citizen science and citizens as they will be discussed. ‘Citizen Science’ evokes a science which assists the needs and concerns of citizens - as the apologists of science so often claim. At the same time, ‘Citizen Science’ implies a form of science developed and enacted by citizens themselves - and one important strand of this book will deal with the ‘contextual knowledges’ which are generated outside of formal scientific institutions. (Irwin, 1995, p. xi)

Irwin focused on the environment and risk as the main arena where the interaction between science and the public played out. One of the main programmatic recommendations reached by Irwin is that science should pay more attention to local expertise. He describes this as a form of extended peer review that incorporates all of the players involved in assessing scientific risk. Irwin emphatically repeats that this is not a rejection of science but a call for increased reflexivity in the practice of science.

> The task is not to remove science from decision-making nor to erode its significance. Instead, questions of citizen science and sustainability present a challenge to integrate scientific expertise with other assessments, problem definitions, and expertises; to acknowledge diversity asa positive element within sustainable development and to appreciate the interconnectedness of 'social', 'environmental' and 'technical' issues and concerns. (Irwin, 1995, p. 173)

For Irwin citizen science is an extended response to contemporary environmental debates in the United Kingdom during the 1980s and 1990s as well as a meditation on the idea of a 'risk society' proposed by the sociologist Ulrich Beck. Irwin glosses Beck's theory in one of the early chapters of *Citizen Science*. Society is now struggling with the problem of overproduction which means that it creates some of its own problems. This leads to an interconnection between Nature and Society that cannot be easily broken or dismissed. Therefore judgments about risk are social and are a reflection of one's position in the social structure. Science, in this new era, becomes both the originator of new risk and the antidote (Irwin, 1995, ch. 2).

The next major use of the term 'citizen science' was American. Rick Bonney, the current director of program development and education at the Cornell Lab of Ornithology, used the term to describe the research tradition that had grown up and guided the development of the Cornell Lab (Bonney, 1996; "Cornell Lab of

Ornithology," n.d.). The Cornell Lab is one of the pioneers in using volunteers to assist scientists in studying birds.

Bonney (1996) calls 'citizen science' a lab tradition at Cornell. He traces the involvement of amateurs in bird observation back to the earliest days of Cornell Lab of Ornithology. The founder of the lab, Arthur A. Allen, solicited New York birders for a database of birds in the New York Cayuga Lake Basin as early as 1929. The science of ornithology is built on the recorded observations of amateurs, from the early 1800s to the start of the Audubon Christmas Bird Counts at the beginning of the twentieth century. Newer projects at the lab, such as Project Feederwatch and the Cornell Nest Box Network, continue the tradition of amateur-collected data.

Two items are of note in Bonney's formulation of citizen science. First is the explicit connection to amateur activity. Many current discussions of crowdsourcing and citizen science talk about the lineage between current volunteer activity and the amateurs of the past. The current variety of citizen science projects and the different levels of participation may make the amateur reference out of date. Second, several of the projects that Bonney mentions predate the widespread availability of the Internet. Project FeederWatch began in 1987, for example. This is relevant to discussions about the historical uniqueness of current citizen science/crowd science programs. Bonney, like many of the proponents of citizen science, legitimizes current citizen science research by appealing to a previous time when such amateur activity was much more common.

Bonney (1996) acknowledges the valuable observations contributed by amateurs and the research that they support. But he also sees benefits for the participants in citizen science. He says "amateur ornithologists become proficient in bird identification, acquire the skills of patient observation, imbibe the process of scientific investigation, and gain the satisfaction of furthering scientific knowledge. The lab also hopes that public participation in bird studies will spawn action on behalf of birds." (7) These few sentences capture the multitude of goals, sometimes aligned and sometimes contradictory, that citizen science attempts to accomplish. Environmental activism, appreciation for science, and individual skills in specific areas are all goals and effects of citizen science research. The many goals sometimes cause problems for evaluation and also reflect ongoing tensions between volunteers as instruments and scientists as educators.

Current definitions of citizen science are a direct outgrowth of the approach described by Bonney in the late 1990s. "Citizen science refers to the engagement of non-professionals in scientific investigations - asking questions, collecting data, or interpreting results" (Miller-Rushing, Primack, & Bonney, 2012). "Citizen science, defined as participation of the general public in scientific research" (Couvet, Jiguet, Julliard, Levrel, & Teyssedre, 2008). "A citizen scientist is a volunteer who collects and/or processes data as part of a scientific enquiry" (Silvertown, 2009).

The definitions are not unanimous and part of the motivation for this current research project is the many different terms and definitions that are used to describe citizen science. These three definitions alone mention non-professionals, the general

public, and volunteers as the primary participants in citizen science projects. It is not at all clear that these groups are the same.

Furthermore there is ongoing discussion about the use of the term 'citizen science' itself. Alternative terms, such as 'public participation in scientific research', 'volunteer-based monitoring', and 'participatory science' have been proposed and used by various researchers and groups within the citizen science community of practice (Miller-Rushing et al., 2012). If one adds other research domains, such as geography or computer science, then additional terms may be applied, such as 'volunteered geographic information' or 'crowd science.' (Franzoni & Sauermann, 2014; Goodchild, 2007) More general terms from outside the scientific research realm may also be applied, such as 'crowdsourcing' or 'user generated content' (Brabham, 2008)

In addition to the growth in terminology there has been expansion in the use of citizen science by various academic disciplines. Leach and Fairhead (2002) connected citizen science to anthropology and the study of 'indigenous knowledge'. McCormick, Brown, and Zavestoski (2003) imported the idea into sociology and applied it to the alliances formed around environmental illnesses. Robertson and Hull (2003) connected it to public ecology. Nerbonne and Nelson (2004) brought in local citizen environmental monitoring projects. Additional authors have made connections to risk management, conservation, and biodiversity (Chilvers, 2007; Cooper, Dickinson, Phillips, & Bonney, 2007; Couvet et al., 2008).

This brief sketch of the history of the term citizen science shows how the term has been used in two major ways. The instrumental-pragmatic use of citizen science

focuses on extending the capabilities of current scientists into areas where they may not be able to effectively or efficiently deploy observers or themselves. The goal is to extend the sensory net of existing scientific projects through the deployment of new technologies and social organizations. The emancipatory-participative use of the term focuses on the potential of bringing non-scientist into discussions about the future and current development of science and technology. The goal is to improve the relationship between democracy, science, and technology by bringing more voices, especially non-experts, into the dialog about science and technology policy.

1.1.2 Typologies

Researchers who study citizen science are faced with a daunting challenge. There are currently hundreds of projects listed at clearinghouses such as scistarter.org. How can this diversity of projects be treated as single form of activity - citizen science? One approach is to create a typology of different projects.

An early attempt to create such a typology looked at local monitoring programs in various countries around the world. To determine whether a local monitoring project would be successful as opposed to a professional project required examining the species that needed to be monitored, the management policies within the area being surveyed, the scale of threats to various environments, and the availability of resources. Thus a national threat would need a professional monitoring solution and high resources. Local trends in species populations would benefit from a low resources local-monitoring project (Danielsen, Burgess, & Balmford, 2005).

Wilderman (2007) looked at the role of the community in citizen science projects. She described three types of projects: community consulting, community workers, and a community-based, participatory research model. The two factors used to classify projects was the role of the scientists and the roles of the community members/volunteers. A community consulting project used community members to determine the scientific problem and then assigned the research task to professional scientists. A community workers model reversed the groups; scientists were the designers and community members gathered the data. The participatory research model had the community involved in all the steps to "define the problem, design the study, collect the samples, analyze the samples, and actually interpret the data" (Wilderman, 2007, p. 5)

Bonney et al. (2009) proposed a similar typology to Wilderman (2007). They focused on the role of volunteers as well. The first category were contributory projects designed by scientists in which the public contributed data. The second category were collaborative projects usually designed by scientists but often refined with help from the public. The final category were co-created projects designed by both public and scientists in which the public continued to be involved through most of the steps in the research process.

More recent attempts at creating a typology for citizen science begin to acknowledge the diversity of projects that can be called citizen science. One approach is to inductively categorize a set of projects. A landscape survey of projects conducted in 2010 found five different clusters of activity and participation: action, conservation,

investigation, virtual, and educational. Each type focuses on different goals although there is often overlap. Action types are focused on local intervention. Conservation projects are aimed at natural resource management. Investigating projects need data collection from the physical environment in order to pursue answers to scientific research questions. Virtual projects forego physical data analysis or collection so all interactions are mediated via virtual environments. Education projects focus on outreach as a primary goal (Wiggins & Crowston, 2011).

Wiggins and Crowston (2012) returned to the problem of typology with another conference presentation a year after the previous typology reported above. This time they contacted some 800 project managers and received responses from approximately 130. They used the responses to create statistical clusters around the goals and tasks of the surveyed projects. Using a list 12 tasks they found 5 clusters of tasks. Some projects were mainly based on observations, others added to the observation task with data entry, species identification, and analysis. Yet another cluster focused on data entry. One of the final two clusters engaged in most of the tasks, while the final cluster focused on observation and data analysis without species identification. A similar set of 5 clusters was found around a set of 10 goals that included science, management, action, education, conservation, monitoring, restoration, outreach, stewardship, and discovery.

The literature described in this section shows that three major factors have been used to classify citizen science projects. The first factor is the relationship between the community and the researchers, both (Bonney et al., 2009) and (Wilderman,

2007) used this method. The other two factors have been the goals and tasks used in a project (Wiggins & Crowston, 2011, 2012). The three factors are not mutually exclusive and the mix of clusters that appeared in Wiggins and Crowston (2012) suggests that many citizen science projects are a mix of the typologies presented here.

1.1.3 Quality and Accuracy

From the start of the citizen science movement the question of data quality has been at the forefront of skepticism about the scientific value of data collected by volunteers. A variety of approaches have been taken to address the data quality challenge. A review of 450 citations from the Web of Knowledge during the course of this study showed at least 40 articles specifically on data quality with the earliest from 2003. Thirty of them have been published since 2012.

A synthesis of data quality techniques published in 2011 showed that most projects focused on potential errors among the protocols and the participants. A multitude of methods were used to address errors, including expert review, photo submissions, participant training, equipment calibration, rating of participants, and more. Data quality procedures were present throughout the research process from before the project began, while data was being collected, and after data was obtained. One recommendation from the synthesis was for projects to put more time into data analysis methods. Such an effort would recognize that data problems were a holistic

challenge throughout the lifecycle of a project not just a challenge for contributors (Wiggins, Newman, Stevenson, & Crowston, 2011).

A detailed survey of data quality among projects dealing with invasive species identified a number of key concerns for data management among citizen science projects. The major constraints on data quality were identified as the availability of resources, the tools for data collection, and the resources for data management. The variable size and resources of citizen science projects makes a single solution impractical and unlikely to succeed. One way to address data collection problems is to improve the design of online and paper forms that are used for data collection. The adoption of field tools such as smartphones or portable GPS devices can also help to improve accuracy. Another way to address data management is to build infrastructure systems that can be used by multiple programs to build the custom data collection interfaces needed (Crall et al., 2010). Citisci.org has already begun that process and is currently supporting 88 active citizen science projects ("CitSci.org," n.d.)

Additional studies of data quality in citizen science projects have taken a number of forms. The most popular are case studies which have covered numerous projects from different disciplines, including oceanography, invasive species, forest monitoring, and environmental monitoring (Cox, Philippoff, Baumgartner, & Smith, 2012; Crall et al., 2011; Fowler, Whyatt, Davies, & Ellis, 2013; Galloway, Tudor, & Vander Haegen, 2006; Gillett et al., 2012). The next most popular approach has been to compare expert and volunteer performance (Gillett et al., 2012; Gollan, de Bruyn, Reid, & Wilkie, 2012; Hoyer, Wellendorf, Frydenborg, Bartlett, & Canfield, 2012; Nerbonne,

Ward, Ollila, Williams, & Vondracek, 2008; Yu, Wong, & Hutchinson, 2010). Most of these studies identify differences between expert and non-expert performance which can usually be addressed through better volunteer training, improvement in data protocols, or additional data validation using machine methods. In fact a number of programs already use algorithmic approaches to dealing with incorrect data (Bonter & Cooper, 2012; Yu, Kelling, Gerbracht, & Wong, 2012). Some studies have pointed out that even the experts can sometimes make mistakes and that rejecting citizen science data because of a fear of volunteer error is misplaced. For most volunteers errors decrease with experience (Cox et al., 2012; Fitzpatrick, Preisser, Ellison, & Elkinton, 2009).

1.1.4 Education

Since the start of the citizen science movement there have been calls for evaluating the educational outcomes of projects. Education is one of the main motivations for many of the researchers who choose to become involved in the creation and management of a citizen science project. Organizations such as the Cornell Lab of Ornithology have contributed significant resources to developing evaluation measures, educational materials, project designs, policy guidelines, and other best practices for citizen science projects (Bonney et al., 2009; "Cornell Lab of Ornithology," n.d.). Citizen science projects are also being integrated with existing outreach programs such as the Audubon annual Christmas bird count, museum programs, and naturalist activities

at parks and other recreation sites. As the number and scope of projects continues to grow the need for program evaluation becomes greater.

Early studies of educational outcomes for citizen science projects either developed their own surveys of project participants or tried to extend existing measures for science understanding and education to the realm of citizen science (Brossard et al., 2005; Trumbull et al., 2000). Initial demographics showed that volunteers were older and better educated than the rest of the population. The knowledge of science among volunteers was quite good and attitudes toward science were positive. Trumbull et al. (2000) attempted to extend the National Science Education Standards to evaluate the types of inquiry that participants engaged in. Letters from participants were analyzed to see if they engaged in behaviors such as hypothesis testing or observations. The researchers concluded that participation in the project led to forms of systematic inquiry, but the data could not be generalized. Brossard et al. (2005) used existing scales of attitudes toward science, attitudes toward the environment, and understanding of the scientific process to evaluate participants in an ornithological citizen science project. The study concluded that understanding about bird biology increased during the project, but no statistically significant alterations in attitudes toward science, understanding of science, or attitudes toward the environment could be found. C. Evans et al. (2005) studied the effects of the Neighborhood Nestwatch program through interviews, emails, and telephone calls. Results suggested that a citizen science project could increase knowledge about science, but those increases were affected by two factors - participant motivation

and interaction between scientists and volunteers. Establishing personal connections between researchers and participants is, however, very resource intensive and may not be appropriate for very large scale citizen science projects. But many other projects do incorporate direct face-to-face interactions and have the potential to benefit the public at different scales.

Bonney et al. (2009) was mentioned earlier in the typologies section. In addition to developing a typology of citizen science projects the report also completed an evaluation of ten projects, 5 contributory, 3 collaborative, and 2 co-created. Projects were evaluated on awareness/knowledge, engagement, skills, attitudes, and behaviors. Improvements in awareness/knowledge, engagement, and skills were found in most projects regardless of type. Changes in attitudes and behaviors are harder to detect and no conclusive evidence was found to show an impact of citizen science on attitudes or behaviors. But anecdotal evidence suggested a potential for positive impacts in both areas.

Continued study of the educational and attitude effects of citizen science have shown mixed positive results or no change. Attitudes toward science are likely to be high in people who choose to volunteer for a citizen science project so measuring attitude change with scales standardized to general populations is less likely to detect change. Contextual studies that look closer at specific skills gained during participation or differences between citizen science volunteers and the general public may be more effective at measuring the impact of citizen science (Crall et al., 2013).

Citizen science is also expanding beyond informal science education into traditional education settings. Undergraduate science education could be improved by incorporating class projects, data collection, and research opportunities into the standard curriculum (Oberhauser & LeBuhn, 2012). Citizen science may also be helpful for reaching underserved populations as demonstrated by the School of Ants project which took its curriculum to South Africa. Resource-poor countries, like much of Africa, are unable to carry out the large-scale surveys needed for biodiversity monitoring. Volunteer programs that overlap with education institutions may be one way to extend the coverage for biodiversity monitoring (Braschler, Mahood, Karenyi, Gaston, & Chown, 2010).

In summary the measurement of education outcomes from citizen science is a challenge. Traditional measures of scientific knowledge and attitudes toward science are often designed for national surveys. The volunteers who participate in citizen science projects are already at the 'ceiling' of knowledge and positive attitudes toward science and thus traditional measures may not show significant effects of citizen science projects. Addressing these 'ceiling effects' is one of the major directions for future research (Crall et al., 2013). The results of research conducted so far indicate positive outcomes from citizen science, including better knowledge about specific scientific subjects, such as ornithology, and continued positive attitudes toward science. Extending citizen science projects into formal education environments may help students become more acquainted with the scientific process. But challenges

remain, especially reaching underserved populations, who may not have the resources to participate in citizen science or the knowledge that such programs even exist.

1.2 Historical Dilemma

The historical dilemma for citizen science is how different contemporary citizen science is from past amateur science activities. One side of the debate argues that crowdsourcing and citizen science, by extension being the application of crowdsourcing to science, is a distinct historical development that is quite different from previous participation by amateurs in science. The other side of the debate sees continuity instead of discontinuity and argues that what we currently call citizen science is the same as previous generations amateur science or volunteer participation. There are cogent arguments to be made for both sides of the debate.

The typical story of the development of science usually starts at the Copernican revolution in the 16th century (Kuhn, 2012; Sagan, 2013) and moves forward through the Enlightenment and into the Industrial Revolution. Most scientists during this time period were amateurs in the sense that they had no professional training in what we today would consider science, nor did they receive any significant remuneration for their scientific activities. It was not until the 19th century that the term "scientist" was first used ("Oxford English Dictionary," n.d.). The development of the research university during the late 19th and early 20th century solidified the professional status of science as an academic discipline (Barry, 2004). Further developments

in the expense of equipment and the cost of coordinating research reinforced the professional structure of science throughout the 20th century and into the post-World War Two environment. Government support became increasingly important for funding research during this time as well (Tietge, 2008).

Amateurs remained involved in science throughout the growth of professional science during the 19th and 20th century but their role was gradually reduced. Some fields remained receptive to amateur participation and even contribution to scientific research. Amateur astronomers continued to contribute observations of ephemeral phenomenon such as supernova, meteors, comets, asteroids, and variable stars. Birdwatchers participated in the annual Audubon Christmas bird count throughout the 20th century. Today these past activities are often connected to the discussion of citizen science and used as precedents for the participation of volunteers in scientific research.

The argument against continuity between amateur science and current crowd science is an extension of arguments made by scholars of crowdsourcing, an alternative term that is used in general to describe projects that depend upon a large group of volunteers to collectively act or complete tasks.

A survey of the scholarly literature on definitions of crowdsourcing concluded with the following comprehensive definition:

> Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes

> to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage what the user has brought to the venture, whose form will depend on the type of activity undertaken.(Estellés-Arolas & González-Ladrón-de-Guevara, 2012, p. 197)

A couple of key points in this definition are the typical presence of organizations that originate the calls for crowdsourcing, a willing audience/crowd able to complete the work, an online environment to mediate the interactions between the crowd-sourced and the crowd, and an activity that leads to mutual benefit Brabham (2008, p. 3).

One can see that all of these key points fit the case of citizen science as it is practiced today. But past amateur/volunteer science activities did not have the internet to rely upon for mediation between volunteer and researcher. Brabham (2008) argues that the "speed, reach, rich capability, and lowered barriers to enabled by the Internet and other new media technologies make crowdsourcing qualitatively

different from the open problem-solving and collaborative production processes of yesteryear." (10)

Whether one agrees with Brabham and others about crowdsourcing being qualitatively different depends on the type of argument one is making. For citizen science researchers and proponents the connection to past amateur and volunteer science activity has been a valuable rhetorical argument which increases the familiarity of citizen science to researchers who may not be aware of the name.

Part of the confusion about the historical roots of citizen science may be the very broad application of the term that has been carried out since its original introduction. Irwin and Bonney used the term quite differently in the later 1990s. The former referring to public interventions in risk and environmental management, the latter referring to the distributed data gathering of volunteers at the Cornell Lab of Ornithology. Shirk et al. (2012) attempted to synthesize the many different historical sources for citizen science in order to create a design template for future projects. They noted that volunteer efforts played significant roles in many areas, including development studies, public health, ornithology, astronomy, water quality monitoring, and natural resource management. Some of these efforts have long historical pedigrees, while others are more recent and depend upon recent changes in technology like the internet. To encompass all of these efforts they proposed an umbrella term of public participation in scientific research (PPSR).

It is too early to judge the success of the various terms that have been used to describe public participation in scientific research. So far 'citizen science' has gained

the most popularity as will be shown in later but the boundaries of this definition, like so many others, are still in flux.

1.3 Success and Limits of Citizen Science

Assessing the impact of citizen science can be a challenge. The outcomes of citizen science projects can be divided into three areas: science, social-ecological, and individual. Scientific outcomes may include advancing scientific knowledge about invasive species, species distribution, life-cycle changes, the spread of diseases, and many more. Estimates of total peer reviewed articles produced range up to a 1000 for eight large-scale projects while particular projects such as e-Bird have produced over 90 academic papers (Bonney et al., 2014; Shirk et al., 2012).

The social-ecological impacts of citizen science have addressed the problem of environmental degradation, improvements to wildlife habitat, growing participant engagement, and better relationships between communities and natural resource managers. Citizen science acts as a forum for feedback between communities and environmental officials. Including participants from the start of the project design process can be an important way to deepened participation and improve social outcomes (Wilderman, 2007; Shirk et al., 2012).

The impact of citizen science on the individual are another subject that has been addressed in the research literature. The section on education earlier in this chapter showed some of the positive outcomes of citizen science for individuals. Studies have

shown increases in individual skills and knowledge of particular scientific subjects engaged in during a citizen science project (Crall et al., 2013; C. Evans et al., 2005). Projects have also had positive impacts on education in different countries and formal academic environments (Braschler et al., 2010; Oberhauser & LeBuhn, 2012).

Two examples of successful projects are eBird and Zooniverse. EBird is a large website for collecting ornithology data from observers spread throughout the world ("Cornell Lab of Ornithology," n.d.). Zooniverse began as a project to classify astronomical images of galaxies and has grown to include additional projects to study the moon, sun, planets, climate history, soldier's diaries, bats, plankton, cancer, and more ("Zooniverse," n.d.). These projects have become exemplars for other projects in a rapidly growing field (Bonney et al., 2014; Newman et al., 2012).

EBird and Zooniverse are examples of contributory citizen science projects in which scientists have posed the research questions, designed the project, and established the infrastructure for collecting or evaluating data. The success of these contributory projects often hinges on appropriate scientific outcomes as described above. Co-created projects may have different criterion for success such as greater engagement for participants, more participation in the design process, and social or political outcomes. Measuring transformative changes in social conditions is very difficult in comparison to counting the number of scientific publications produced by a project (Lawrence, 2006; Rowe & Frewer, 2005) Science and technology scholars have begun to address the question of how to measure public engagement with science and will be discussed further in chapter 2.

One area of research has investigated occasions when members of the public have directly intervened in science or medicine. One prominent example is the AIDS activist movement during the 1980s and 1990s. Activists from multiple organizations lobbied government agencies and scientific researchers to reduce the amount of regulations on drug trials. Reducing the regulations had the effect of turning some AIDS sufferers into experimental subjects for the testing of new drugs. A change that was justified because of the dramatic health impact of AIDS. The academic interest in the genesis of patient groups has grown significantly over the past 20 years. More groups have formed and been successful in their goals of lobbying for changes to the medical system and the provision of healthcare. Science and technology scholars have been particularly interested in patient groups because they bring to the forefront key epistemic and social issues such as the definition of the body and diseases (Epstein, 2008). Still other scholars have noted the growth of social movements which are explicitly interested in science and technology subjects. The environmental movement is one example which includes sub-movements in opposition to technologies such as nuclear power, and movements to develop alternative science or technologies such as organic foods. Other movements are intervening in health care and information management arenas (Hess, Campbell, & Martin, 2008). The amount of public participation in scientific research supported by each of these movements is quite different. Some movements may be satisfied with changing the priorities of existing scientific groups while other movements may become experimenters on themselves or direct observers of the environment. The results of this research into

public participation in scientific research show that the area is growing. An increasing number of people are becoming involved in science, technology, and medical research policy. The public is clearly interested in being involved with scientific research.

Critics of citizen science may approach the phenomenon from at least two different perspectives. Some criticize the quality of science produced by citizen science projects. They assume that non-experts are unable to complete quality research on the level of a professional scientist. Many of these objections have been addressed through direct study of data quality. A number of these studies were discussed earlier in this the section on quality and accuracy earlier in this chapter. The results of those studies have consistently shown that non-expert observers can do as good a job as professional scientists given the right circumstances and support. Projects must be designed to provide training and quality infrastructure in order to accomplish high-quality science. (Crall et al., 2010, 2011; Wiggins et al., 2011)

Another criticism of citizen science is that it does not go far enough to support community action on scientific and technical questions. The key to this challenge is the argument that just completing a set of scientific observations is not sufficient for participation in the policy making process. Standards are setup to shut-out public data gathering and raise barriers between experts and non-experts. Citizen science needs to go beyond monitoring to attack the standards themselves in order to overcome the boundaries which may prevent citizen action in environmentally degraded areas (Ottinger, 2010).

Citizen science stands at the intersection of two different dimensions. On the one hand there is a spectrum from low to high intensity knowledge production, on the other is a spectrum from sponsored activity supported by professionals to spontaneous social movements (Bucchi & Neresini, 2008). Citizen science is high in knowledge creation sponsored by professional scientists. It is by no means the only, or necessarily the best, way for the public to interact with science. However, it is a novel way to include non-scientists in the knowledge creation process. Previous social movements may have needed to ask scientists to modify a research agenda to reflect the concerns of the movement. Now members of the public can begin their own research projects or contribute to existing projects from professional scientists.

1.4 Research Questions

Communication and information scholars should care about citizen science for a number of reasons.

First, communication is a key component for project creation, management, and sustainability. Citizen science projects depend upon the efforts of volunteers who need to be recruited, motivated, and rewarded for their participation. Communication and information science researchers can contribute to the development of better methods for exchanging information between scientists and volunteers.

Second, citizen science is growing in importance as an interface between science and the public. Concern about the interaction between the public and science

has a long history (Gregory & Miller, 1998). The public understanding of science movement, begun in the 1980s, has developed a long-term concern with measuring the relationship between science and the public (Russell, 2009). A greater understanding of citizen science may contribute to better understanding of the relationship between science and the public, which is one of the research questions addressed in this dissertation.

Third, the mass media play a major role in the distribution of information about most scientific findings and activities (Logan, 2001). Communication scholars have studied the media effects of different communication frames in many different settings (Maibach, Nisbet, Baldwin, Akerlof, & Diao, 2010; Nisbet, 2009; Nisbet & Scheufele, 2009; Stewart, Dickerson, & Hotchkiss, 2009). Studying the communication of science in a citizen science setting may reveal new insight into how communication frames are formed, and how new forms of scientific method/research are described in the media.

Fourth, there is a gap in the existing literature regarding communication processes in citizen science. The literature reviewed in this chapter shows that majority of articles about citizen science have focused on accuracy or education. An even larger group of articles report specific results for a project but very few articles discuss the communication processes or media interactions involved in citizen science. This is a gap that can be filled by the current study which attempts to answer the following research questions.

1. What are the frames for citizen science in different discourse communities?

- Among scientists
- Among public relations professionals in academic settings
- Among science writers reporting on topic of citizen science

2. How are these frames created?
   - How does information travel from experts to non-experts?
   - How is the information framed for each community on the line from scientist, to press officer, to journalist, to volunteer?
   - How is the information framed differently depending on context, situation, and audience?

3. How does citizen science alter the relationship between public(s) and science(s)?
   - What are the social worlds where citizen science communication occurs?
   - What is the social structure of citizen science projects, in particular their communication infrastructure?
   - Who controls these relationships between scientists and publics?
   - What are the institutional structures for the context of citizen science?

Chapter 2

Conceptual Review

The purpose of this chapter is identify key concepts for the discussion of the relation between science and the public in light of the development of citizen science over the last two decades. Citizen science lies at the intersection of a number of trends in multiple scholarly disciplines. The concepts in this chapter introduce some of these disciplines in a focused way meant to highlight their interconnections with citizen science. The concepts were used to formulate both interview and research questions during the research process. In this sense the introduction of these concepts fit with what Herbert Blumer called 'sensitizing concepts.' (Blumer, 1954)

According to Blumer a sensitizing concept "gives the user a general sense of reference and guidance in approaching empirical instances. Whereas definitive concepts provide prescriptions of what to see, sensitizing concepts merely suggest directions along which to look." (7) The concepts introduced in this chapter

— science, public, citizen, expert-novice, amateur–professional, and participation–engagement — are implicated in the development of public participation in science.

The topics also provide a roadmap of the different areas that are potentially affected by citizen science such as boundaries, the development of different publics, integration of citizenship and big data, and the future of expertise. The discussion of these topics is currently divided among a number of different academic disciplines: information science, communication, science and technology studies, philosophy, and sociology. Outlining these concepts demonstrates the potential interest of multiple disciplines in the problem of citizen science.

It also points to some of the concluding discussions that will be opened up through the analysis of the empirical data collected during this study. Questions about whether science, or any rationalist Enlightenment activity, can liberate itself from instrumental reason from within? What does public understanding really mean for science? Is it confined to greater scientific literacy among the public or does it portend greater participation in the complete process of scientific life? These questions are not answered in the current chapter but the topics discussed will set the background for their discussion in later chapters.

A note should be made at this point about the different historical eras that are covered in the forthcoming sections on sensitizing concepts. Some concepts, such as science, are set in a modern context since the Renaissance, other concepts, such as citizenship, are contextualized back to the Greeks and Romans. The different contextualizations reflect the current scholarly discussion of each topic. Science can

be traced back to the Greeks and Romans but most of the intellectual activity is focused on changes since the Renaissance. Citizenship discussions, by contrast, still reference the Greeks and Romans quite prominently.

2.1 Science

The definition of science encompasses two broad ideas: the idea of knowledge or knowing and the particular branches of study or inquiry ("Oxford English Dictionary," n.d.). The former is a philosophic definition of science focused on the process of acquiring and verifying knowledge. The latter is a social definition focused on the structure and membership of groups engaged in the acquisition of knowledge. Debates between these different versions or visions of science arise in many different locations. Sociological or historical studies of science are likely to focus on the idiographic particulars of how a science developed during a particular time. Philosophical studies are likely to focus on nomothetic goals or procedures that are relevant to all sciences at all times. The different definitions may even be seen to be the roots of the ongoing debate between quantitative and qualitative research paradigms.

The tension between these two views of science can be seen in the discourse around popular science and public outreach. On the one hand scientists are encouraged to explain their findings to the public reducing much of science communication to the process of transmitting information. More recent discussions in the public understanding of science movement have shifted away from a transmission paradigm

to one of public engagement (Brossard & Lewenstein, 2009; Gregory & Miller, 1998). Public engagement seeks to move beyond the transmission of scientific findings and convey to the public a sense of the process of science and the scientific method. Whether such a transition can be successful is still debated.

Citizen science is one example of how the transition to a publicly engaged science may happen. The goal of a citizen science project is to explicitly persuade the public to help a project collect or analyze data. The problem is how much engagement is actually allowed or occurring within the project. Engagement spans a spectrum from very limited contributions where volunteers may simply be asked to take a survey or classify images. More engagement may occur when the volunteers are consulted about the design or formulation of the project. Still more engagement may occur when volunteers are engaged from the start to the end of a project to formulate research questions and complete project presentations or publications. Bonney et al. (2009) characterized these different levels of participation as contributory, collaborative, and co-created. All three levels involve the public but the amount and type of involvement varies.

The relationship between science and the public has been historically variable. The definition of both science and the public have shifted over time. The next section of this chapter will address some of the different definitions of the public that have been proposed.

Science cannot be itself without some form of public communication. Shapin and Schaeffer described an early modern example of public science in their book

the "Leviathan and the Air Pump" (Shapin & Schaffer, 1985). During the scientific revolution of the early 17th century there was an argument between Thomas Hobbes and Robert Boyle about what type of evidence was acceptable for the newly developing natural sciences. Hobbes argued that rational cogitation was enough to discover new facts about science; Boyle countered that experimentation carried out in public in front of witnesses was the preferred method for scientific exploration. Boyle's vision of experimental science became the preferred method for verifying and testing scientific explanations of the natural world. Shapin continued his investigation of early science in "A Social History of Truth" (Shapin, 1994). He broadened his argument to include the learned societies and early published journals as evidence of how science has always been dependent upon public communication of its findings. Vickery (2000) traced the many forms of scientific communication, including journal articles, encyclopedias, indexes, and abstracts. As science has become more complex the need for rapid summaries of scientific discoveries led to publishers and authors who summarized findings into abstracts and indexes. Today the internet is one of the major distributors of new findings and discoveries in science through pre-print archives, open access repositories, and data sharing services.

Merton (1996) identified four ethical attributes of science: universalism, communism, disinterestedness, and organized skepticism. Universalism means that scientific claims are not judged based on personal criteria of any kind; particular conditions in a society or a country should not affect the evaluation of science. Communism means that the discoveries of science are assigned to the community and not a particular

individual; discoveries are supposed to be publicly shared and are part of the common heritage of science. Disinterestedness is an institutional factor not a matter of individual motivation. The institutions of science promote peer responsibility, success or failure is measured by others not the individual. Organized skepticism is embedded in methods and institutions where scientific beliefs are questioned without regard to their social standing (Merton, 1996, pp. 266-276). All of the four attributes identified by Merton depend upon the public communication practices embedded in the institutions of the sciences.

Merton's attributes paint a positive picture of scientific investigation but there have been skeptical responses since Merton proposed his scheme in 1946. Science and technical studies and the strong program in the sociology of knowledge have argued that there are definite interests, biases, and politics at work in science (Sismondo, 2003). Many of these criticisms are valid but the image presented by Merton is still important to the self-perception and even the societal perception of scientists (Small, Kushmerick, & Benson, 2008). Even citizen scientists may appeal to the ethical attributes of science as part of their motivation for joining a project.

The ethical principles presented by Merton tend toward openness but there are simultaneous demands for boundary making and demarcation of science from other human endeavors. Karl Popper, one of the foremost philosophers of science in the twentieth century, was deeply concerned about the problem of demarcating science from other endeavors. Popper wrote his major work "The Logic of Scientific Discovery" in 1934 during the height of the Vienna circle, one of the major groups

promoting logical positivism during the years between World War 1 and World War 2. Popper's major goal in "The Logic of Scientific Discovery" was twofold: provide a way of separating science from other disciplines - the problem of demarcation, and to resolve the problem of induction that had bedeviled philosophy since David Hume. Hume argued that there was no way to be certain about causation because all we could observe in the world was the constant conjunction of events, not the causes that may link them. Popper responded to both problems with the idea of falsification. Science did not assert truths about the world, instead it made conjectures that could be tested, or falsified, by empirical evidence. Scientists developed theories, derived hypotheses, and then tested those through experiments. The result were not truths but tentative conclusions about the world. Falsification distinguished science from other metaphysical questions such as the existence of God by arguing that science progressed through the refinement of conjectures that could always be falsified at some future time. It resolved the problem of induction by arguing that science functioned through deduction from the theories proposed by scientists. Thus science functioned by testing the deductions made from theories not by induction from observations of the world (Popper, 2002; Benton & Craib, 2011). Popper has been used by scientists and their defenders to declare different forms of pseudoscience outside the bounds of normal scientific inquiry.

But the drawing of boundaries around science is not as clear a process as Popper claimed. Sociologists and other students of science have increasingly realized that the boundaries between science and other inquiries are drawn for a variety of reasons,

not all of which are rational. Thomas Gieryn (Gieryn, 1999, 1983; Gieryn, Bevins, & Zehr, 1985) has completed a number of studies that look at the formation of boundaries between scientists and other groups. Depending upon the rhetorical goals of scientists, science can be framed along different spectrums from completely empirical to completely theoretical, entirely pure to entirely applied. Gieryn uses the rhetoric of John Tyndall, phrenologists, national security, and the evolution-creation debate to demonstrate the ambiguous nature of scientific boundaries. "The boundaries of science are ambiguous, flexible, historically changing, contextually variable, internally inconsistent, and sometimes disputed." (Gieryn, 1983, p. 792) The reasons for boundary creation and conflicting definitions include the need to respond to different challenges, to deal with multiple professional goals, and the simultaneous pursuit of disparate goals.

Boundaries can be negotiated and crossed in multiple ways. Star and Griesemer (1989) identify two ways that boundaries are managed: methods standardization, and boundary objects. The primary research site for their work is the Museum of Vertebrate Zoology at the University of California, Berkeley. At the museum they found that the early standardization of collection methods by early curators led to a culture that included diverse groups such as professionals and amateurs.

> Boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identify across sites. They

> are weakly structured in common use, and become strongly structured in individual-site use. These objects may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds (Star & Griesemer, 1989, p. 393)

In the context of the museum some examples of boundary objects are the geographic terrain of California, the habitat of collected animal species, and the physical factors of the environment in California. The idea of boundary objects can be applied beyond the specific site chosen by Star and Griesemer to any location where different social worlds intersect such as citizen science.

The key points from the preceding literature about science are the following:

- Science is a social activity which depends upon communication between scientists.
- Scientific communication is necessarily public for historical and ethical reasons.
- Boundaries between science and other activities are constantly under construction and destruction.

2.2 Public

Understanding the public is crucial for the success of the current project. One of the background assumptions of this project is that citizen science, by virtue of incorporating both scientists and members of the public, has the potential to alter the relationship between science and the public. The goal of this section is to describe the importance of the public to science and to describe three philosophic definitions of the public.

Defining the public is a difficult process. People are members of many different publics, ranging from their local neighborhoods, to larger national and international organizations or collections of people. Speaking of a general need for the public to better understand science is likely to cause as much confusion as clarification. Since the beginning of the public understanding of science movement in the 1980s there has been a growing recognition that there is no single public that must be addressed when communicating science. A physicist may have little or no knowledge of biology making her part of the general or lay public when it comes to understanding biology (Gregory & Miller, 1998).

Talking about the public also performs a salutary rhetorical function to encourage participation in everyday life. Phrases about 'public service', 'public spirit' and 'public scrutiny' are used positively far more than they are used negatively (Gregory & Miller, 1998). Public participation may even be considered a virtue that is further linked to the duties of citizens within a nation or a community. Choosing between

the phrase 'citizen science' and the phrase 'public participation in scientific research' becomes an important part of the discussion about the values inherent in including the public in scientific projects.

The default assumption of many is that public participation is valuable for democratic reasons. An informed citizenry becomes one of the driving goals for public understanding of science and further outreach efforts by scientists. Citizen science can fit into some of these projects and fact they can be used as justifications for the further expansion of citizen science programs.

The concept of the public and the concept of science do not have a single meaning or connotation. But there is sometimes value in speaking of the public and science in the singular. The terms are frequently used singularly in the English language discussions about science policy and governance. Another theoretical reason for using these terms in the singular is to connect with the philosophical and historical discussions about science communication, the philosophy of science, and criticisms of scientific rationalism that have been lodged by some critical theorists.

Three theorists of the public that are important to the current study are John Dewey, Jurgen Habermas, and Nancy Fraser. Dewey produced his major work on the public during the first quarter of the twentieth century. Habermas began working on these problems during the 1950s. Fraser is a major critic of Habermas and expanded the vocabulary surrounding discussions of the public by introducing the concept of 'counterpublics'.

John Dewey was an American philosopher who made major contributions to the development of pragmatism, one of the influential branches of American philosophy. Pragmatism is a school of philosophy that began in the United States during the late nineteenth century. Pragmatism remained a significant feature of American philosophy into the middle decades of the twentieth century. One of major tenets of pragmatism was the consideration of consequences. Ideas, objects, and actions were to be considered based on the effects or practical bearings they might have (Hookway, 2010; Menand, 1997).

Dewey applied this idea to his analysis of the public in "The Public and Its Problems" (Dewey, 2008). Dewey wanted to defend the idea of democracy and the public against those who thought the idea was no longer relevant in modern America. Dewey defined the public based on the consequences of individual actions. "The public consists of all those who are affected by the indirect consequences of transactions to such an extent that it is deemed necessary to have those consequences systematically cared for." (Dewey, 2008, p. 245) The state and government become the systematic response of people to the problems that have been caused by other people, problems that cannot be resolved through individual or small group responses.

After defining this descriptive form of the public, Dewey uses the remainder of the book to discuss the prescriptive function of the public. Dewey was a strong defender of democracy throughout his career and he used that background to outline a defense of democracy and the development of a public that is aware of itself and able to make changes to the policy of the state. He argues that the primary problem of the

public was “to achieve such recognition of itself as will give it weight in the selection of official representatives and in the definition of their responsibilities and rights.” (Dewey, 2008, p. 283) The problem is that the public is barred from self-understanding by business, factions, political parties, and other groups which use representative government to promote their own interests instead of the public interest. The remedy for this problem is local democratic communities which have access to the benefits of scientific social inquiry.

Jurgen Habermas is one of the most influential social theorists of the twentieth century. His contributions extend the developments of critical theory, a school of social thought that originated in 1920s Germany and attempted to address the problems of modernity. Critical theorists noted with concern the growing influence of phenomenology, which claimed to determine the conditions of all human consciousness, and positivism, which proclaimed the preeminence of the natural sciences for understanding the social world. The result was increasing alienation through the exploitation of labor and the reification of individuals removed from their contextual situation. It was a response to the triumph of mass production. World War Two accelerated their critique and led to a general questioning of the principles of rationality and democracy that had driven the Enlightenment. How could humanity praise rationality after the industrial horrors of Auschwitz and the Holocaust? After World War Two the major critical theorists such as Horkheimer, Adorno, and Marcuse deepened their criticism of a mass media age that reduced human beings to cogs in the machine of capitalism (Bronner, 2011).

Habermas began his career by writing about the public sphere in the 1950s. His first book "The Structural Transformation of the Public Sphere" (Habermas, 1989) is a philosophical-historical reconstruction of the Enlightenment and the rise of a public sphere that was capable of influencing the state and government. According to Habermas the public sphere arose at a unique historical moment when the bourgeois class became large enough and communication technologies like the newspaper became significant enough for there to be private discussions about the proper nature of public activity.

"The Structural Transformation of the Public Sphere" is primarily descriptive. It concentrates on the historical moment of the Enlightenment and attempts to show how and why the public sphere arose during that time in history. Habermas presents his prescriptive version of the public in other works, such as the "Theory of Communicative Action." (Habermas, 1984) In that work the main emphasis is upon communication as the basis for social interaction and community, a view that Habermas shares with Dewey. But Habermas is much more conscious of power and inequality than Dewey. Habermas explicitly states that communicative action must take place without coercion. If coercion exists then it is just another expression of power and hierarchy not a true act of communicative action. He also argues that communicative action can be used to settle disputes between people and groups. For this to occur everyone needs to agree upon a basic criterion of rationality. It is this emphasis on rationality that has led to many misreadings and disagreements with Habermas.

Nancy Fraser (Fraser, 1990) is a prominent critic of Habermas. Her objection is that the view of the public sphere described by Habermas is inherently inegalitarian. Historical research reveals that the public sphere of the Enlightenment included only a small group of people usually white males with significant social standing. Fraser concludes that no such limited group could express the goals for democracy that we now have. In opposition to these groups there are 'subaltern counter publics' which work counter to the privileged public of the status quo in order to gain more rights for disadvantaged groups. One example she uses is the feminist movement of the twentieth century which has worked diligently to create more opportunities for women to participate in public activities of all kinds.

All of these ideas are connected to the definition of public understanding of science. In order for such an understanding to progress there must be some conception of the public, explicit or implicit. Science and technology studies acknowledge that there are different types of public dependent upon situation. But there is still a lot of discussion within science communication that relies upon a deficit model in which the public is just a vessel to be filled with the correct scientific information. Other models of science communication invoke ideas of lay expertise, contextual understanding, or broader movements for public understanding and participation (Brossard & Lewenstein, 2009).

Citizen science is one example of a move toward greater participation by the public in scientific research. The question is what type of participation will it generate. The purpose of this section has been to:

- Identify the complexity of the public and the multiple functions the idea of the public can perform.
- Describe three theorists of the public: John Dewey, Jurgen Habermas, and Nancy Fraser
- To connect definitions of the public to the problem of citizen science and public understanding of science in general.

2.3 Citizen

The appellation "citizen science" presents a unique analytical challenge to the student of the topic. Just what is it that connects citizens and science? In order to understand this topic it is necessary to describe a part of the historical and contemporary conversation about citizenship. Current conversations about citizenship are still influenced by historical concepts extending back to the time of the Greeks and Romans. The contemporary conversations about other sensitizing topics in this chapter do not extend as far back in history. The reasons why the citizenship discussion refers back to the Greeks and Romans is due to the philosophical history of citizenship. This section begins by defining citizenship and describing the historical contrast between republican and liberal conceptions of citizenship.

Bellamy (2008) defines citizenship as:

> a condition of civic equality. It consists of membership of a political community where all citizens can determine the terms of social cooperation on an equal basis. This status not only secures equal rights to the enjoyment of the collective goods provided by the political association but also involves equal duties to promote and sustain them - including the good of democratic citizenship itself. (17)

He identifies three components of citizenship: membership, rights, and participation. Other authors have identified similar components but applied slightly different terminology. Leydet (2009) mentions legal status, political agency, and membership. Cohen (1999, p. 248) describes these as a political principle of democracy, juridical status of legal personhood, and a form of membership. The balance between these three components has shifted over historical time. In addition, recent changes in the global economic/political environment and the growth of identity politics present challenges to the traditional conception of citizenship.

The historic discussion of citizenship is usually defined by reference to the history of the Greek and Roman societies. Two major traditions of thinking about citizenship arose from these historical roots. The first, called the "republican tradition", traces back to the Greek city states and emphasized the obligations of citizens to participate in government and public affairs. Political participation becomes the central purpose of citizenship; the focus is on the "equality of citizens as rulers and makers of laws" (Bellamy, 2008, p. 29) The "liberal tradition", tracing back to Rome and the

Enlightenment, emphasized the rights of individuals to equal treatment under the law (Bellamy, 2008; Leydet, 2009).

The appropriate balance between obligation and rights continues to be a topic of current discussion. Some have argued that current societal trends are devaluing citizenship through the growth of consumerism and the decline of political community. Potential responses to the perceived decline in citizenship include more participatory fora for people to express their opinions and citizenship education (Bellamy, 2008).

The rights and obligations of citizenship are particularly interesting because they can be enforced through the use of political power and thus establish a direct relationship between a government and people.

> Citizenship designates a set of mutually enforceable claims relating categories of persons to agents of governments. Like relations between spouses, between co-authors, between workers and employers, citizenship has the character of a contract: variable in range, never completely specifiable, always depending on unstated assumptions about context, modified by practice, constrained by collective memory, yet ineluctably involving rights and obligations sufficiently defined that either party is likely to express indignation and take corrective action when the other fails to meet expectations built into the relationship. As observers, we actually witness transactions between governmental agents and members of broadly-defined categories, but we abstract from those transactions a

cultural bundle: a set of mutual rights and obligations. (Tilly, 1997, p. 600)

Tilly identifies the multiple contingencies which comprise the idea of citizenship. The difficulty of completely specifying the concept, its dependence on context, practice, and memory. But it still carries the character of a contract for which corrective action can be taken to make sure that contract is enforced. In contrast the idea of a public may seem a bit feeble.

Science and technology scholars have linked participation and citizenship on a number of occasions. Irwin's initial book on 'Citizen Science' is one example. He returned to the topic by reviewing the activities of the Public Consultation on Developments in the Biosciences (Irwin, 2001). Irwin noted a number of design criteria for progressing toward greater scientific citizenship including a balance between information and consultation, the degree of activity by citizens, the extent of pre-framing by elites, and the institutional location in which consultation occurs. He concluded that "the relationship between science and democracy should not be about the search for universal solutions and institutional fixes, but rather the development of an open and critical discussion between researchers, policy makers, and citizens." (Irwin, 2001, p. 16)

While Irwin's call for scientific citizenship is a bit vague, Frankenfeld (1992) is much more detailed with his proposed technological citizenship.

> equal membership,participation,and standing or status of persons as agents and subjects within a realm of common impact to at least one "technology" – or instance of consciously amplified human capacity – under a definable state that governs this technology and its impacts. Such status is defined by a set of binding,equal rights and obligations that are intended to reconcile technology's unlimited potentials for human benefit and ennoblement with its unlimited potentials for human injury, tyrannization, and degradation. Such status,rights, and obligations are thus intended to reconcile democracy for lay subjects of technology's impacts with the right of innovators to innovate. TC reconciles the autonomy of laypersons with the autonomy of experts.It thus affirms autonomy in general. TC affirms human freedom, autonomy,dignity, and assimilation of people with fellow people and with their built world. (Frankenfeld, 1992, p. 462)

The roots of such a definition can be seen in history of public participation-engagement with science described in section 6 of this chapter. Sustained challenges to science and technology created an environment in which the role of citizens vis a vis technology was reexamined. It is important to note that Frankenfeld explicitly brings the dual nature of citizenship into his discussion of both rights and obligations. Rights to information, informed consent, participation, and limits on endangerment

are balanced with obligations to use knowledge for self-validation of safety, accept the will of the majority, and exercise technological civic literacy (Frankenfeld, 1992).

The use of the term 'citizen' in the phrase 'citizen science' raises the same issues. Citizenship is a valuable rhetorical tool in the arsenal of science critics because of its long historical pedigree, its connection to democracy, and its connection to civil rights. It encompasses a broad swath of political concepts that go beyond the idea of a public. Citizens are included in the democratic decision making process without any need to justify their presence. Science and technology discussions often come with barriers, such as technical knowledge, which separate those with knowledge from those without. Citizens are already invested in their local communities, and thus concerned about science and technical issues which affect them.

There is also a drawback to using the term 'citizen' to describe public participation in science. In addition to having connotations regarding rights and obligations, citizen can also connote exclusion. Citizenship may exclude some people from the protection of the law, much less the ability or right to participate in scientific research. Political and moral philosophers have addressed the problem of exclusion in a number of ways.

One argument against citizenship attacks universalist claims that people can overcome their particular points of view in order to adopt a general perspective for viewing common problems. By rejecting universalist claims, citizenship can be reconceived as a differentiated concept dependent upon context. The discussion over the balance between differentiated citizenship and the needs for an integrating function for citizenship continue to be argued within the academic literature. (Leydet,

2009). Some scholars advocate a multilevel model of citizenship which attempt to acknowledge the many different social positions people may occupy (Maas, 2013).

The implication of exclusion for citizens science is an important matter and should not be rejected out of hand. At the same time, there are potential benefits of using the the rhetoric of citizenship to promote science and public participation in general. Benefits for democracy and for science. Technoscience does not determine the future of society and integrating citizens in decision-making is one important way of shaping the future uses of science and technology (Feenberg, 2010)

The purpose of this section has been to

- Introduce some key concepts from the philosophical discussion of citizenship.
- Show how those concepts have been adopted by science and technology scholars.

2.4 Expert-Novice

Expertise is relevant to the study of citizen science for a number of reasons. First, questions which are raised about the accuracy of citizens science compared to other scientific methods often rest on definitions of expertise and experience. One purpose for training professional scientists is to give them the expertise to make judgments about appropriate scientific methods. Second, expertise is not purely a matter of performance or successful collection of data. There is a social component to the definition of expertise which raises a number of questions for citizen science including who is allowed to participate, which data is considered valid, and the overall design of

projects. Third, the analysis of expertise, especially in science and technology studies, influenced some of the early definitions of citizen science (Irwin, 1995). These early conceptions explicitly defined citizen science as a way to access the knowledge of non-scientists involved in technological development.

The study of expertise crosses many different academic fields including psychology, philosophy, computer science, engineering, and sociology. There is no single definition of expertise that guides all of these studies partly because so many different fields contribute and partly because the boundaries of expertise are fluid. Expertise is never static, it changes, slowly and quickly, depending on a myriad of factors from social status to death to task change.

K. Anders Ericsson is one of the prominent psychologists who have studied expertise and expert performance over the past two decades. The "10,000 hour rule" popularized by Malcolm Gladwell in the book "Outliers" comes from Ericsson's research; according to Gladwell it takes most people 10,000 hours of practice to reach a level of skill that can be called expert (Gladwell, 2008). Deliberate practice that is focused, programmatic, and carried out over a period of time is one of the few psychologically tested recommendations for the development and improvement of expertise (Ericsson, Krampe, & Tesch-Römer, 1993).

Ericsson distinguishes between two concepts of expertise. The first is expert performance that can be measured using standardized tests and benchmarks. Chess players and musicians are common examples of such expert performance because they have clearly obtained skills that can not be matched by the average chess player or

musician, much less the average person who has no experience in those domains. For these cases there are agreed upon standards by which members of the domain and outsiders judge great performance.

The second concept of expertise is based on social recognition and peer nomination. Business auditors, stock analysts, and psychotherapists are some examples of experts who are often recognized by their peers but do not necessarily perform better that non-experts. (Ericsson, Charness, Feltovich, & Hoffman, 2006).

At face value these two types of expertise seem to parallel the disciplinary boundaries between psychology and sociology. Psychology focuses on highly superior skills based upon "basic abilities, knowledge, and acquired skills" (Ericsson, 2006, p. 4). Sociology, by contrast, is interested in the social settings for expertise and the cultural conditions that lead to its development and support.

Evetts, Mieg, and Felt (2006) review the history of the sociological study of expertise in their contribution to the "Cambridge Handbook of Expertise and Expert Performance". They identify three main areas of concern: professions, scientists, and elites.

Professions have been of interest to sociologists from the beginning of the discipline, and can be seen in the work of early theorists such as Durkheim and Weber. The functionalist turn in sociology treated professions as a stabilizing force in modern society. Evetts et al. (2006) identify a number of waves in the study of professions from the initial interest in functional value to a focus on institutions, professionalization, and occupational control. The connection between

professions and expertise is justified for operational necessity because in order to study the phenomenon boundaries must be set and experts are already associated with professional groups, so why not use professions as an example of expertise.

Scientists are the next significant group of experts to have been studied from a sociological perspective. Evetts et al. (2006) identify three parts to the study of scientists. Historical studies have looked at the development of scientific expertise and the notions of objectivity, fact, and discipline (Daston, 1992; Shapin & Schaffer, 1985). Microsociological studies have focused on the behavior of scientists in the laboratory (Latour & Woolgar, 1979). Gender concerns have been raised over the number of women in science and also over the epistemology of science. Broadly speaking all three of these approaches can be subsumed under the umbrella of the social studies of science.

The final area of sociological study are elites. Evetts (2003) trace the sociological discussion of elites back to early Italian sociologists such as Pareto, Mosca, and Michels. This early analysis of elites was directly concerned with power. Pareto defined elites as those who were "most capable in any area of activity" (p. 118). Today the term elite is more often applied to those with the most power, not necessarily the most capability. Weber proposed three methods for the transfer of elite power: heredity, charisma, and merit. Merit in turn became the major way to legitimize the bureaucracy of modern society. Conflict arises when the support for merit conflicts with other Enlightenment beliefs, such as democracy. "Expertise is not

easily comprehensible by lay citizens, democratic control of the expanding activities of experts..is more questionable than ever" (Evetts, 2003, p. 119).

Another research domain that has dealt with the study of experts is science and technology studies. Over the past 40 years the field of STS has examined the grounds for accepting the decisions of scientists and technologists when it comes to making decisions which may affect a public. The so-called second wave of science studies arose in parallel with the strong program in the sociology of knowledge which was initially based in Edinburgh. During the 1970s and 1980s a number of significant studies attempted to demonstrate the social construction of scientific knowledge (Knorr-Cetina, 1999; Latour & Woolgar, 1979; Sismondo, 2003). A landmark study of Cumbrian sheep farmers affected by fallout from Chernobyl set the stage for questioning the divide between scientific experts and layman (Wynne, 1993). Wynne found that scientists gave advice to local farmers without considering their local expertise in soil conditions and environment. The result was a shifting series of recommendations by the experts about when the area would be safe for grazing. The standards used by the experts were based on laboratory experiments that proved to be inadequate for understanding the local conditions. Since then many studies have argued that ignoring local expertise in technical decision making was morally and practically mistaken.

The argument over the proper role of experts in policy making and technical decision making intercepted the history of citizen science in Alan Irwin's book "Citizen Science" (Irwin, 1995). Irwin explicitly built upon the previous work of scholars like

Wynne to argue that citizen science could become a new paradigm for interactions between citizens and scientists. In his argument the primary question for citizen science was how to effectively incorporate local knowledge and non-expert information into science and technical decision making.

Collins and Evans engaged the debate on expertise in (Collins & R. Evans, 2002) with a major paper proposing a third wave of science studies: studies of expertise and experience. According to Collins and Evans the then current state of discussions about expertise in STS were caught between two problems: the problem of legitimacy and the problem of extension.

> Though science studies has resolved the Problem of Legitimacy by showing that the basis of technical decision-making can and should be widened beyond the core of certified experts, it has failed to solve the Problem of Extension: 'How far should participation in technical decision-making extend?' In other words, science studies has shown that there is more to scientific and technical expertise than is encompassed in the work of formally accredited scientists and technologists, but it has not told us how much more.

They proposed a typology of expertise and a typology of science in order to help answer the problem of extension. For experts they suggested a three-level classification: no expertise, interactional, and contributory. The categories are meant to be understood from the perspective of a social scientist investigating science. The

first level, no expertise, represents a fieldworker who is entering a new area for the first time without any previous experience. The second level, interactional expertise, means that the fieldworker has gained enough experience to interact with people involved in the science and is now capable of performing a sociological analysis of the field. The third level, contributory expertise, is for fieldworkers who have gained enough experience and knowledge about the topic of study that they are capable of making contributions to the science that is being studied (Collins & R. Evans, 2002).

Science and technologies can likewise be classified into different types. An "integral public expertise in public-use technologies" encompasses the use of technologies that a majority of the population has access to is familiar with its use. Examples might include personal computers and automobiles. Uncertified expertise is often part of the development process for these technologies. The next type is "integral public expertise in local-interest technologies." The primary example here is local planning. In this type people become experts by virtue of their long-term experience in a particular location. This type of expertise needs to be balanced against experience with larger scales beyond the local. Finally there is the "esoteric and controversial sciences." In these areas the involvement of the public is, by definition, not integral to the advancement of knowledge or the implementation of technologies. The sciences can be further subdivided based on degrees of controversy. "Normal science" is free of major disputes; the science is settled. Scientists may serve as consultants about these topics without controversy. "Golem science" is still unsettled and has not yet reached the level of closure found in "normal science." Scientists will probably reach

a consensus at some time and there is no reason not to expect politics to accept the conclusions of the scientists involved in this research once those conclusions have been reached. “Historical sciences” are unlikely to be closed anytime soon among the scientific community. These sciences deal with historical trends that cannot be replicated in the laboratory and are thus closure is very difficult to achieve among the core-set of scientists involved in the research. Finally there are “reflexive historical sciences” where uncertainty becomes even more likely. Global warming is the best example of a “reflexive historical science” because it depends on past events, which cannot be repeated or tested in a laboratory and also is directly connected to political decision-making. Social conditions become as important to settling the problems raised by historical sciences as ‘pure’ scientific expertise (Collins & R. Evans, 2002).

The purpose of examining expertise in the context of citizen science has been to:

- Describe the different intellectual traditions that have studied the topic of expertise.
- Provide examples of expert studies from psychology, sociology, and science and technological studies.
- Establish a typology for discussing different levels of expertise and science which will be used later in the dissertation to discuss the particular case of citizen science.

2.5 Amateur-Professional

Professional scientists were mentioned as a category in the previous section. The analysis and study of professions is also important to understanding the social world and context of current developments in citizen science. The literature on the topic of professions overlaps in some cases with the literature on expertise but there are some clear differences. The study of professions has flourished in sociology while the study of expertise has done better in psychology and STS. This section draws a contrast between expert and professional. Furthermore, there is a clear analytic difference between expert and professional because one can be an expert without necessarily being a member of a profession. The appropriate contrast is between amateurs and professionals, not experts and professionals. Citizen science crosses both expert and professional boundaries and thus needs to draw on the background of both fields.

The initial studies in the sociology of professions grew out of the work of Max Weber on bureaucracy and Emile Durkheim on the division of labor. They both recognized that modernity had led to the creation of sophisticated organizations that required new forms of labor certification. The scholars that followed Weber and Durkheim in the 1920s to the 1960s attempted to develop a typology of professions and define professions based on particular characteristics, such as access to certifications and specialized knowledge (Abbott, 1988; Sciulli, 2005). Further developments within this tradition treated professions from a functional perspective and attempted to explain how they helped control society and keep it stable (Evetts, 2003).

The next wave of professional studies, starting in the 1970s and continuing through the 1990s, took a revisionist approach and challenged the prestige of professions. Researchers noted that professions were a way of protecting institutional and occupational power instead of only promoting specialized knowledge or building ethical community standards. The second wave scholars argued that professions were politically motivated ways of displaying dominance and the asymmetry of experience (Abbott, 1988). Many argued that monopolies were malevolent and that there were no empirical distinctions between different professions, all of them were engaged in the same protectionist practices to control the boundaries between the profession and the rest of the world. The most recent work on professions has withdrawn somewhat from the critical attitude of the second wave scholars (Sciulli, 2005).

To define a profession has been a challenge throughout the history of scholarship on the topic. (Evetts, 2003, p. 397) writes that "professions are essentially the knowledge-based category of occupations which usually follow a period of tertiary education and vocational training and experience." Others, such as Abbott (1988), have focused on particular cases and avoided hard definitions although he has explained professional groups as exclusive occupational groups that apply abstract knowledge to particular cases. Abstraction of knowledge and the maintenance of jurisdictional boundaries are key to professional activity according to Abbot (Abbott, 1988).

Sciulli (2005) responds to the reluctance of some sociologists to propose analytical definitions of professions by arguing that there are invariant qualities that distinguish professions from mere experts. Professions are placed in a structured situation from

which they provide expert services. These structures support the power, trust, and discretion of professionals. In other words, professionals are able to “achieve a degree of closure around an area of work” (Allsop et al., 2009). By contrast an expert occupation may lack an entrenched position and provide services in a more fluid manner; professions have well-defined institutional structures that funnel and control points of access and knowledge distribution. There is no such guarantee of structure for the expert. Professionals are also involved in advancing the well-being of their clients, and advancing the institutions of the profession within the society, which Sciulli (2005) refers to as fiduciary responsibilities.

Freidson (2001) defines professionalism as making a living from ones own work and involves specialized training and resistance to standardization leading to a “third logic” for organizing work. The first logic is the market where people work to fulfill the demand for labor. The second logic is bureaucratic where work is controlled by a managerial class that assigns tasks to subordinates. The third logic is professional or occupational where workers define their tasks based on their professional knowledge, experience, and membership.

One can observe from this summary that a key dynamic for understanding professionals is control. Being a professional involves an ability to control the access to, knowledge needed, and certification for activity within a specified domain. Comparative studies of professions have been quite useful to identifying some of the themes within the tradition. Evetts (2003) identifies some of the differences between

the Anglo-American tradition and the continental European tradition. Anglo-American scholarship has focused on key professions such as medicine and the law, resulting in a focus on market protection and monopolies. Freedom to control working conditions and individual self-employment have been central pillars of the Anglo-American research, while the continental European tradition has focused more on elite government administrators and direct connection to the public sector (Evetts, 2003).

Control is also an important aspect of contemporary discussions with science and technology studies about the proper role of non-scientists in science and technology decision making. Collins and R. Evans (2002) described a common periodization of science studies into first and second waves. The first wave, predominant during the 1950s and 1960s, was focused on understanding science and reinforcing its success. The second wave, starting in the 1970s, began to question the superiority of science. Science was increasingly treated as a social construction that depended on factors beyond the traditional, such as theory and experimentation, to include the social, including institutions and political factors. The third wave turns to the study of expertise and seeks to deal with the combined problems of legitimation and extension. The shifting attitudes toward expertise parallel the changing attitudes toward professionals described in this section. In fact skepticism about professions and the science both occurred during the 1970s.

Thomas Gieryn, a sociologist of science, was mentioned earlier in this chapter during the discussion of boundary-setting in science. Boundaries are another major

way that professions define themselves with respect to other groups. Gieryn et al. (1985) present a study of how boundaries were managed in two legal trials over the teaching of evolution in American schools. They compared two cases, the Scopes trial from 1925 and the McLean trial from 1981-82. In both trials scientists distinguished themselves from non-scientists but the particular rhetorical strategies used were different. In the Scopes trial the defenders of science tried to show that science provided a unique intellectual commodity, namely "true and useful knowledge about nature", and was not necessarily in conflict with religious beliefs. At the second trial the argument shifted to exclude creationists from scientific legitimacy by portraying creationism as a form of pseudoscience. The first trial showed science and religion as complements while the second trial portrayed them as competitors. Gieryn et al. (1985) conclude that different images of the relation between science and religion were used at different times to manage the boundaries of public science. The key point from this story for the current discussion is the willingness of scientists to use claims to professional experience as a way to negotiate the appropriate boundaries between the science and the public.

The sociological study of professions is quite advanced in comparison to the social study of amateurs. The most prominent theorist of amateurs has been Robert Stebbins who began publishing a set of landmark studies on amateur activity in the late 1970s. The work of Stebbins and others has been labeled the serious leisure framework.

Stebbins (2007) describes a number of types of leisure including serious and casual varieties. Serious leisure is the relevant category for the purposes of this paper and is defined as “the systematic pursuit of an amateur, hobbyist, or volunteer core activity that people find so substantial, interesting, and fulfilling that, in the typical case, they launch themselves on a (leisure) career centered on acquiring and expressing a combination of its special skills, knowledge, and experience.” (Stebbins, 2007, p. 5) Amateurs are distinguished from hobbyists and volunteers by existing alongside a professional community engaged in similar activity. Amateurs are linked to professional counterparts who pursue similar activities for economic gain. The visibility of the professional community provides an aspirational goal and a model for amateurs to compare and measure themselves against. Stebbins calls the intersection between public, amateur, and professional the P-A-P complex.

Amateurs and professionals share a number of mutually dependent links according to Stebbins (Stebbins, 1982a). Both groups may serve the public, for example amateur and professional astronomers may both participate in star watching parties, or professionals may carry out research while amateurs provide education and dissemination of the results of research. There are often organizational, and occasionally monetary, links between both groups. Intellectual ties also exist with amateurs sometimes acting as “gadflies” to encourage professionals to uphold high standards of work. Furthermore, many professionals begin their careers as amateurs. According to Stebbins (1977) amateur should only be used in situations where a professional career opportunity exists. Thus a canoeist, even though very good, is

probably not an amateur because there is no parallel professional status as a canoeist. Instead this person is more appropriately called a hobbyist.

Applying these concepts to citizen science suggests that project volunteers could be called amateurs under the serious leisure framework because they exist a shared system with professionals and publics.

The purpose of this section has been to:

- Describe the sociological study of professions and suggest a definition for a profession.
- Introduce the serious leisure perspective and its studies of amateur activity
- Suggest some of the ways in which scientists have protected themselves as a profession.

2.6 Participation

One important way of understanding the context for citizen science is to look back at the history of public-science interactions. Technology, especially the internet, has dramatically changed the modes of interaction between volunteer and scientist but not at the expense of continuity with previous efforts to link public and science. This section will review some of the history of this interaction between science and the public. A number of key terms in the evolution of this relationship are understanding, engagement, and participation. Each of these terms have become key labels for

different intellectual movements concerned with public-science interactions over the 20th century.

The popularization of scientific information has a lengthy pedigree which can be traced back to the mass media and publishing industries during the 19th century. In the early 20th century a number of professional science organizations introduced media bureaus to present research to a mass audience. Lewenstein (1992) argues that these efforts led to the valorization of science and increasing social authority for the products of scientific research. After World War Two the popular understanding of science was treated as a mode of appreciation. The public was seen as a blank audience for appreciating science which would lead to further support for science-in-general and research funding in particular. Four groups – commercial publishers, science writers, scientific organizations, and government agencies – converged on the promotion of greater public understanding of science.

> Yet each group, despite different rationales, adopted similar definitions, focusing on disseminating technical information about the discoveries of science. It seemed to each of these groups that this was what 'the public' – whatever public they happened to be talking about – wanted. And this was a field in which what the producers of information defined as 'wanted' was what got produced, with little sense of what the various publics might choose on their own. Each definition focused on promoting an *appreciation* of science, and especially the 'benefits' of science to society. Though

> much of the rhetoric of these groups talk about improving the public's *understanding* of the relationships between science and society, in practice they meant improving the public's *appreciation* of the benefits that society received from science. (Lewenstein, 1992, p. 62)

This attitude toward 'public understanding' began to be critiqued from a number of avenues during the 1960s and 1970s. A number of philosophers and commentators including Jacques Ellul, Martin Heidegger, Herber Marcuse, and Lewis Mumford began to question the role of technology in modern society (Ellul, 1964; Heidegger, 1977; Marcuse, 1964; Mumford, 1963). The social protest and environmental movements overlapped with this questioning of technology. Jurgen Habermas, in Germany, became involved with both of these intellectual movements.

Lengwiler (2008), in a historical review of public participation in science, noted four periods in the relationship between science and technology – hybrid, politicized, autonomous, and participatory. Starting in the 19th century, with the hybrid model, the roles of scientist and policy maker were often mixed. Social utopians, such as Fourier and Saint-Simon, grounded their political programs in science. Science became increasingly politicized with the rise of large research universities and the development of technocratic governance in politics during the early 20th century before World War Two. States became more involved in the funding of science research as well. After World War Two, science became increasingly autonomous. Funding agencies dispersed significant resources to basic research programs which

were selected and evaluated by other scientists. A mutual benefit relationship between the public and science was established. The public funded science and left control of the process to scientists, in return for technological and medical breakthroughs which advanced lifestyles and the economy. The final era is the participatory. Science was displaced from its throne, its autonomy questioned, and new forms of governance put in place. The rise of environmental and medical activist groups forced scientists to adapt to new forms of public participation in scientific research.

Today scientists need to realize that knowledge claims include a social component. The 'deficit' model of science appreciation described by Lewenstein is difficult to sustain. The public is involved in the co-production of knowledge and policy in a number of areas. Activist groups have successfully advocated for changes in medical research program. The most prominent example are AIDS activist groups who altered drug evaluation programs during the height of the epidemic in the 1980s and 1990s. Other diseases, like muscular dystrophy, have attracted their own advocates and funders. Environmental activists have lobbied hard against genetically modified organisms and been especially successful in Europe (Munro & Schurman, 2009). Changes have also occurred in legal forums and repurposing technology for other uses (Bucchi & Neresini, 2008).

Formal efforts to include the public in science and technology policy making have proliferated through a number of venues and countries. Rowe and Frewer (2005) list over 100 different methods that have been used to engage the public with science and technology. They divide these programs based on the 'flow of information'. Public

communication programs move information from sponsors to the public, for example information broadcasts and public hearings. Public consultation moves information from public to sponsor and can range from focus groups to citizen juries. Public participation programs engage in two-way transfers between sponsors and the public. Action planning workshops, task forces, and town meetings are some examples of public participation mechanisms. Citizen science ideally meet the criteria for public participation. Evaluating these types of projects requires paying attention to how members are selected, the type of facilitation that occurs, whether response is open or closed, where information comes from, how information is transferred, and how responses are aggregated (Rowe & Frewer, 2005).

The interaction of science with the mass media can also be recontextualized to parallel the discussions so far. The one-way public understanding of science model can be described as a 'science-dominated public sphere' characterized by science driven news framing, fears of science being inaccurately portrayed, and limitations on controversy. The more engaged 'contextualized scientific public sphere' shows science as one among many forms of knowledge which is legitimized by society and controlled through public negotiation. Each model slightly shifts the standing of scientific actors, the available positions that can be taken, and the frames/interpretations that can be offered in the media. Empirical research on the human genome debate in Germany and the United States showed that scientists dominated the debate by being granted the highest standing, and influencing the dominant frames used to discuss the issues (Gerhards & Schäfer, 2009).

All of this background contributes to current discussion about citizen science and public participation in scientific research. Haywood and Besley (2014) name the two traditions 'public understanding of science and technology' (PUST) and 'public engagement in science' (PES). The former emerges directly from the history described by Lewenstein and Lengwiler above. The focus is on more education and greater outreach to the public. The latter attempts to open up the scientific process to more actors through new forms of engagement beyond just education. Citizen science, again, seems to be at the forefront of ways to engage the public in science (Haywood & Besley, 2014).

Two final points need to be made in this section of the dissertation. First, science is not the only endeavor that has seen rise of a participative public. Popular culture has also seen dramatic increases in participation by members of the audience, especially in specific genres such as science fiction. Fandom continues to grow across many different media (Jenkins, 2006). Second, it may seem to some as though science has lost out during the developments of the participatory era described above. Scientific knowledge no longer has unchallenged access to the public sphere. Philosophically this should be considered a positive change. Science could never really separate itself from society or become autonomous for long. Scientists are members of the public too, and thus responsible in then same way that every citizen is (Douglas, 2003).

The purpose of this section has been to

- Describe the movements between different eras of public participation in science.

- Discuss some of the many mechanisms for public participation in science.
- Connect citizen science to the changing landscape of public participation in science.

The concepts of science, public, citizen, and expert all play a role in the discussion of citizen science as it is currently taking place. The definitions and backgrounds for these terms shape the debate. The purpose of this chapter has been to expose a tiny sliver of the large discussions that surround these topics in order to develop them in relation to citizen science.

Chapter 3

Theory

The purpose of this chapter is to explain the theoretical background used to inform the analysis of citizen science presented in this dissertation. The background is divided into four major sections. The first is on social worlds, arenas, and grounded theory. This section sets up the foundations of the major methodological paradigm used in the study. The second section is on communication framing. Together these first two sections form a larger section that describes the objects of analysis studied in this dissertation.

The third section introduces a critical element into the discussion. This section describes the work of John Dewey, in particular his theory of inquiry. The previous chapter briefly mentioned Dewey in connection with defining and understanding the concept of a public. That discussion is amplified in this chapter. The fourth, and final section, of this chapter deals with the work of Jurgen Habermas. Habermas is one of the most well-known critical theorists alive. His work sets the stage for

examining a number of concepts relevant to this dissertation: the concept of the public sphere; rationalization and science; and communicative action. These concepts are described in this section in preparation for their application in the final chapters of the dissertation.

3.1 Evidence

The first half of this chapter deals with theories about evidence used in this dissertation. It uses theory as a building block to point toward aspects of the world that will be helpful in answering the research questions posed in chapter 1. These aspects of the world that are indicated by theory will then be used during the analysis of results to provide support for the interpretations, judgments, and arguments made.

3.1.1 Social Worlds

The concept of a social world arises from developments in grounded theory and symbolic interactionism. Grounded theory was outlined by Glaser and Strauss (1967) in the late 1960s and early 1970s as a legitimation of qualitative inquiry in the social sciences. The growth of social sciences after World War Two had created an intellectual climate where quantitative studies dominated and qualitative evidence was considered incapable of being as rigorous as quantitative research (Benton & Craib, 2011; Gouldner, 1962). The constant comparative method of analysis attempted to combine coding of data and theory development into a complete process.

A researcher would proceed in four steps, first by comparing multiple incidents during the process of data gathering, second categories would be integrated, third a theory would be described, and fourth the actual writing of a theory (Glaser, 1965). By laying out a programmatic approach to qualitative data gathering and analysis Glaser and Strauss hoped to help improve the credibility of qualitative research and focus the attention of the researcher on the development of theory (Glaser & Strauss, 1967; Glaser, 1965).

Symbolic interactionism traces back to the works of the American Pragmatists, including William James and John Dewey. The pragmatic notions of language as a form of symbolic interaction, the interpretation of experience, and the idea that truth is made not discovered were combined by George Herbert Mead and Herbert Blumer with a sociological perspective to develop the concepts of symbolic interactionism. The sociological interpretation led to three key ideas: action is based in meaning - people behave toward objects based on the meanings those objects have for them; human interaction generates meanings over time – thus meaning is a collective process created by multiple people interacting over time; and interaction can modify meanings – meanings can be transformed through interactions within the self and with others (Lindlof & Taylor, 2010).

Anselm Strauss began the process of codifying a "social worlds perspective" during the 1970s. He noted that a number of sociologist in the Chicago school of sociological analysis mentioned the idea of a social world in non-systematic ways. By building on the ideas of thes scholars Strauss hoped to provide a new tool for explaining

the processes of social change. A social world according to Strauss was focused on a cluster of activities that took place in particular sites usually using some type of technology. An organization may evolve out of the activity to further divide the labor that goes into the creation and maintenance of a social world. Furthermore, there are ongoing processes that affect the evolution of social worlds over time. Social worlds intersect and overlap with each other leading to the sharing of resources between multiple worlds. Social worlds can also segment into subworlds. In other words, the space of social worlds is fluid. “It is a universe where fragmentation, splintering, and disappearance are the mirror images of appearance, emergence, and coalescence. This is a universe where nothing is strictly determined.” (Strauss, 1978, p. 123). Strauss concluded that a social worlds perspective would affect interactionist research programs in a number of ways. Social worlds could be studied at any scale, and in fact the study of multiple scales should be incorporated into the research process. Processes are a central feature of social worlds and need to be a focus for researchers. By looking more closely at social worlds the social sciences would be obliged to pay more attention to the history and the development of social worlds (Strauss, 1978).

A social world perspective was taken up by a variety of scholars, mostly in sociology, over the ensuing decade (Unruh, 1980). Social worlds were unlikely to have strong central control structures because of the diverse number of actors and practices involved. This meant that involvement in a social world was often a form of voluntary identification with the activities of that world. It was possible to be involved in multiple social worlds with different degrees of participation. Participation

was often mediated through different forms of communication such as newspapers, newsletters, radio, and television. A corresponding level of involvement could be mapped to most members ranging from strangers to tourists, regulars, and insiders. Strangers were a necessary oppositional category of people who were not part of the social world. Tourists were driven by curiosity but lacked significant commitment to the social world. Regulars habitually participated in the activities of a social world and provided stability over time. Insiders were strongly connected, to the point that identifying with the social world became a major part of their identity. Common structural features of social worlds included organizations for coordinating the activity of members, communication centers to extend relationships beyond physical loci, geographic centers which may overlap with communication centers but also represent locations where people live, and subworlds which are divisions within social worlds that arise spontaneously throughout the process of social world formation (Unruh, 1980).

> Social worlds...generate shared perspectives that then form the basis for collective action, while individual and collective identities are constituted through commitments to and participation in social worlds and arenas. Commitment was understood as both part of identity construction and as predisposition to act. Strauss and Becker then more ambitiously defined social worlds as groups with shared commitments to certain activities sharing resources of many kinds to achieve their goals, and building

shared ideologies about how to go about their business. Social worlds are universes of discourse and principal affiliative mechanisms through which people organize social life. Insofar as it meaningfully exists, society as a whole, then, can be conceptualized as consisting of layered mosaics of social worlds and arenas. (Clarke, 2005, pp. 45-6)

All of this background is meant to situate one of the major theoretical and methodological roots of the current study. Situational analysis is an extension of grounded theory that is meant to "push grounded theory around the postmodern turn." Clarke identifies five goals for situational analysis. First, reducing the reliance of grounded theory on positivist philosophies of research. Glaser and Strauss developed grounded theory in an intellectual environment that was dominated by quantitative methods. Since then qualitative methods have become more accepted across the social sciences (Benton & Craib, 2011). Clarke wants to abandon some of the positive trappings of grounded theory in her transformation to situational analysis. Second, she wishes to supplement the core metaphors of grounded theory, social process and social action, with the idea of social worlds and arenas. This move combines the original view of grounded theory with the later work of Strauss. Third, she adds cartographic metaphors and methods as a supplement to focusing on actions/processes. Cartography becomes an important metaphor for understanding socal worlds. Fourth, Clarke emphasizes the ongoing process of theorizing. Theory-building accompanies the whole research process and is not confined to a final step

before publication. Fifth, situational analysis supports the development of multisite research designs by including multiple types of evidence, including interviews, documentary and visual materials (Clarke, 2005).

In conclusion, situational analysis extends grounded theory in a number of ways that are conducive to the current study. STS research is one of the disciplines that has taken up situational analysis as a theory/method package that can be applied to multiple research sites (Clarke & Star, 2008). Using some of these methods and theories is one way that the current dissertation connects with current research in science and technology studies.

3.1.2 Communication Framing

Research on frames derives from two major disciplines in the social sciences: psychology and sociology (Borah, 2011). Psychologists working during the 1970s discovered that the description of equivalent logical choices could influence the choices made by people. For example, describing an outcome as a loss or gain affected choices even though the mathematical results were actually the same (Brossard, 2010; Entman, 1993). These effects are considered to be part of the "frame in thought" (Chong & Druckman, 2007) and are believed to be part of basic cognitive structures (Kahneman, 2011). The sociological approach to framing is usually derived from the work of Erving Goffman. Frames are interpretive schema that people use to organize what they encounter in everyday life. Goffman focused on examples from interpersonal communication between individuals and small group

communication although he never rejected the idea of frames being found in mass communication (Goffman, 1974). Media studies scholars began to focus on these "frames in communication" (Chong & Druckman, 2007) during the 1980s. For these scholars the focus was on the messages created by the mass media and then broadcast to the public. The current section summarizes select topics from within the larger literature of framing studies that are relevant to the research questions posed in earlier chapters.

Two key parts of framing theory are the idea of selection and salience. A communication frame:

> select(s) some aspects of a perceived reality and make(s) them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation for the item described. (Entman, 1993, p. 52)

Salience "means making a piece of information more noticeable, meaningful, or memorable to audiences" (Entman, 1993, p. 53) For example, the frame of the "cold war" affected media coverage by focusing attention on some events and giving an explanation (communism) and making moral judgments about those events. Frames thus function to define a problem, suggest a cause(s), make moral judgments, and propose remedies. Furthermore, frames are located throughout the communication process in the communicator, text, receiver, and culture. Communicators and receivers posses "frames in thought" which guide their attention to information

while “frames in communication” are manifested in textual and cultural forms. In particular, textual frames are “manifested by the presence or absence of certain keywords, stock phrases, stereotyped images, sources of information, and sentences that provide thematically reinforcing clusters of facts or judgments.” (Entman, 1993, p. 53) These manifestations will be the key evidence gathered for answering the research question of what frames are currently used to describe citizen science.

Frames can also be defined as “organizing principles that are socially shared and persistent over time, that work symbolically to meaningfully structure the social world.” (Reese, 2010, p. 11) The organizing function of frames crosses both cognitive and cultural dimensions which may go beyond the level of basic thematic similarity. The idea of a principle emphasizes that frames are abstract constructs that are not limited to a single symbolic manifestation. Thus a frame may be indicated by the presence of a specific keyword or stock phrase but it is not simply composed of these linguistic features. Frames extend beyond specific linguistic features by virtue of their shared and persistent nature. They areshared by multiple people and become part of the routine presentation of information. Frames are transmitted through symbolic communication, most often through various types of media such as print, video, and audio. The structuring function of frames “impose a pattern on the social world, a pattern constituted by any number of symbolic devices.” (Reese, 2010, p. 17) Together the parts of this definition extend the concept and study of framing beyond a singular focus on selection and salience to include power and institutional support.

> What power relationships and institutional arrangements support certain routine and persistent ways of making sense of the social world, as found through specific and significant frames, influential information organizing principles that are maintained in identifiable moments of structured meaning and become especially important to the extent they find their way into media discourse, and thus available to guide public life. (Reese, 2010, p. 19)

From a more political perspective framing can be considered a form of strategic public action. Frames are built to attract support, mobilize action, expand influence, and raise the chance of winning public debates. Frames are ways of influencing public discussion

> Thus, we argue that framing is a strategic action in a discursive form. It involves political actors making sense of an issue and participating in public deliberation . . . framing is a discursive means to achieve political potency in influencing public deliberation. It is an integral part of the process of building political alignments. Achieving such political goals through framing involves weaving a web of subsidies and building a 'discursive community'. (Pan & Kozicki, 2001, p. 59)

A web of subsidies represent the different ways that actors draw on resources to spread their message. All people, both elites and non-elites, use frames throughout their ordinary lives in order to interpret incoming information. The framing power of

some actors is more potent than others because of access to material resources, key strategic alliances, and greater experience in frame sponsorship. Frames also build discursive communities.

> We begin with the point that frames define the boundaries of the discourse concerning an issue and categorize the relevant actors based on some established scheme of social taxonomy. In this way, framing can be seen as a means for community building, although the nature of the resulting community is hardly traditional. We do not mean a sociologically close-knit unit in a confined geographic area but a transitory and discursively bound aggregate, capable of collective action in deliberative politics. (Pan & Kozicki, 2001, p. 41)

Pan and Kosicki are describing the creation of a social world based on the framing of particular issues. Their concern is how public and political deliberation constitute a community. The community of citizen science is a partial response to the growing call to increase public deliberation around science and technical issues. This topic was mentioned in chapter 1 during the discussion of Irwin (1995) and will be further discussed in chapter 5.

Both Pan and Kosicki and Reese extend the study of frames beyond a simple identification of words or phrases used in the discussion of a topic. Community and process become important locations for the study of framing. Frames are also placed

at the center of public action and meaning making becoming part of a larger process of communication.

The process of framing an issue in the media can be conceptualized as a process of "frame building; frame setting; individual effects of framing; and a link between individual frames and media frames (i.e. journalists' and elites' susceptibility to framing processes)" (Scheufele, 1999) Frame building studies the process of how frames are created. External factors, such as the form of organizations, professional values, audience expectations, and the actions of other elites may affect the decisions of journalists. Frame setting is the process that connects media frames to audience frames. Many studies vary the presentation frame of a news story in order to demonstrate effects in the dependent variable or audience frame (Scheufele, 2000). The individual effects of framing study how an audience frame affects the beliefs and attitudes of an individual in the audience. The final link goes from individual journalists, who are just as likely to be affected by framing effects as any member of the mass media audience, which then becomes another input into the frame building process (Scheufele, 1999). The whole development of public meaning is a cycle that integrates the members of an audience, the mass media, and the people who speak through the media. In conclusion research on news framing can be described as a research program that shares a number of core assumptions but has different paradigmatic interpretations.

> The hard core of the news framing research program is reflected in four empirical goals that individual studies pursue to varying degrees. These goals are (a) to identify thematic units called frames, (b) to investigate the antecedent conditions that produce frames, (c) to examine how news frames activate, and interact with, an individual's prior knowledge to affect interpretations, recall of information, decision making, and evaluations, and (d) to examine how news frames shape social-level processes such as public opinion and policy issue debates. (D'Angelo, 2002, p. 873)

According to D'Angelo there are three different paradigms under which news frame research can be carried out: cognitive, constructionist, and critical.. Most researchers within each of these paradigms would accept the 'hard core' described above but give different interpretations of the actions by public and members of the media. D'Angelo describes the images of the three paradigms as negotiation, co-optation, and domination, respectively. Critical scholars are more likely to see media hegemony and the exclusion of some viewpoints from media coverage. Constructivists agree that some news frames become dominant for periods of time but there is still room for alternative viewpoints. They also "believe that news organizations limit the range of information about a topic because journalists judge that there are few credible sponsors (i.e., sources) about the topic". (D'Angelo, 2002, p. 877) The current study

blends parts of the critical and constructionist paradigms, deemphasizing the analysis of power, but still keeping a critical watch over the discourses of citizen science.

Science Communication and Framing

Framing research can be used by science communicators "to motivate greater interest and concern; to shape preferences for policies informed by or supportive of science; to influence political or personal behavior; to go beyond polarization and unite various publics around common ground; to define policy choices or options; and/or rally fellow scientists around shared goals or strategy." (Nisbet, 2009) One particular area of focus for frame researchers has been on science-related issues that are controversial, such as evolution or climate change. One study reported the use of a public health frame for global warming issues. They found that framing global warming as a public health issue had a positive response among a variety of segments of the public. It was most effective among those who were already concerned about global warming but also showed positive effects among those who were cautious, disengaged, and doubtful about climate change (Maibach et al., 2010). Frame analysis has also been used to study the responses of people to different news texts about stem cells. In one experiment researchers presented three different articles to readers. The first article used a political conflict frame, the second an economic prospect frame, and the third a science progress frame. The researchers found a significant interaction between ethical evaluations of adult and embryonic stem cell research when presented with a conflict frame. Other frames showed smaller effects (Stewart et al., 2009).

Translating the results of scientific research involves framing at multiple levels of the communication process. An interesting insight into the framing processes of scientists is provided by the emails that were stolen from the Climatic Research Unit in late 2009. Newspaper reports initially suggested that the scientists exchanging information through these emails were employing 'tricks' in order to support their conclusions about anthropogenic global warming. Ryghaug and Skjolsvold (2010) used these emails to study the deliberations of scientists as they grappled with the ways their research should be strategically positioned in order to prepare for likely controversies in the public and how methodological uncertainties could be dealt with. The analysis showed that nearly half of the exchanges dealt with issues related to appropriate framing of the results. The scientists were well aware of the potential controversies their research might raise when finally released and were anxious to show how the evidence for global warming was still supported despite uncertainties in the data. The email list also functioned as a community and 'core group' that wrestled with, and tried to determine the best data for reconstructing past climates (Ryghaug & Skjolsvold, 2010). One can conclude that framing is an activity which occurs among all groups, including scientists, involved with the production and dissemination of knowledge.

Determining the appropriate frame for a scientific issue can be quite challenging. Kendall-Taylor, Erard, and Haydon (2013) used an innovative three-part test in order to find a successful frame for the psychological topic of executive control. They began with on-the-street interviews to test the effectiveness of different metaphors

for describing the development a child's ability to focus. Next they tested the most successful metaphors in a quantitative experiment. Finally they conducted persistence trials to see how well the metaphors held up when being communicated to another person. They concluded that an "air traffic controller" metaphor was the most successful metaphor for communicating the concept of executive control to nonscientists (Kendall-Taylor et al., 2013).

All of these research efforts argue against the default assumption of many scientists who assume that the public will agree with them once they have been given all of the information on an issue. The results of cognitive framing research show that people rarely make decisions on purely informational grounds instead they depend upon emotion, habit, and other cognitive shortcuts. Science communication researchers call the default assumption that more information will resolve science communication problems, the 'deficit model.' (Brossard, 2010) The deficit model is the oldest science communication model and still quite persistent among scientists themselves. More recent models have developed a more nuanced view of the public and its relationship to scientific information. Brossard identified three other models within the science communication literature. The 'lay expertise' model argues that laypeople have local expertise which can be harnessed to help understand a problem. The 'contextual model' argues that laypeople understand science based on their contextual experience which is quite similar to framing theory discussed in this dissertation. The final model is the 'public understanding' model which says that laypeople should be integrated into science and technical discussions. All three frames recognize that adding more

information is not enough for science communicators to succeed. They also need to present their message to the public in a frame that the public can make sense of (Goffman, 1974; Nisbet & Mooney, 2007). Framing addresses the challenge of science communication by bringing the message into the context of the recipient instead of simply serving the needs of science.

Mass communication is still the primary way most people learn about scientific issues (Logan, 2001). The particular frames commonly used by the media in science communication can be divided into eight major types (Nisbet, 2009; Nisbet & Scheufele, 2009). Table 3.1 lists the eight major frames found in studies of science communication in the mass media and gives brief definitions of each type of frame. These frames will be used for the content analysis described later in this dissertation.

Synergies Between Framing and Social Worlds

There are a number of pertinent overlaps and synergies between framing theory and social world theory. Communication plays a crucial role in both theories. Frames, especially when studied in the media, are all about communication, how it works, and what gets transmitted or constructed. Social worlds depend on communication for self- and group-definition, helping to set the boundaries between different types of members, and creating a sense of identity within groups.

People fill different roles within a social world and framing is needed in order to define those roles. Roles are built and maintained through relationships between people which are communicated and constructed through language. Taking on a role

Table 3.1: Science Communication Frames

Name of Frame	Definition
social progress	improving quality of life, or solution to problems. Alternative interpretation as harmony with nature instead of mastery, sustainability.
economic development/competitiveness	economic investment, market benefits of risk; local, national, or global competitiveness.
morality/ethics	in terms of right or wrong; respecting or crossing limits, thresholds, or boundaries.
scientific/technical uncertainty	a matter of expert understanding; what is known versus unknown; either invokes or undermines expert consensus, calls on the authority of 'sound science', falsifibility, or peer-review.
runaway science/Pandora or Frankenstein	call for precaution in face of possible impacts or catastrophe. Out-of-contrl, a Frankenstein's monster, or as fatalism, i.e. action is futile, path is chosen, no turing back.
public accountability/governance	research in the public good or serving private interests; a matter of ownership, control, andf/or patenting of research, or responsible use or abuse of science in decision making, politicization.
middle way/alternative path	around finding a possible compromise position, or a third way between conflicting/polarized views or options.
conflict/strategy	Defined science related issues as...a game among elites; who's ahead or behind in winning debate; war; battle of personalities or groups (usually journalist-driven interpretation)

may require strategic action and communication with others in a group in order to accomplish goals and maintain boundaries.

Science communication requires many different people and roles. Citizen science, in particular is a multi-role endeavor. There are scientists and researchers who design studies, collect data, and publish results; project staff, especially in larger, well-funded organizations, who manage the daily activity of knowledge production; the public information officers who transmit the ideas and discoveries produced by researchers working on projects to a wider audience; and the journalist/writers who transmit ideas to the general public. All of these people play a role in the transmission of project information which is framed by the backgrounds, and cognitive experiences of each person involved.

3.2 Criticism

A few brief comments about criticism and critical theory need to be made at this point in order to set the background for the following sections on Dewey and Habermas.

Three valences of criticism justify the forthcoming discussion in this section. First, is the concept of rhetorical criticism which can be linked directly to framing studies. In this domain criticism is "look[ing] at these efforts - intentional or not - to persuade and influence." (Kuypers, 2010, p. 209) This harkens back to two of the paradigms identified in framing research, critical and constructivist (D'Angelo, 2002), and both may take a rhetorical approach to the study of media framing.

Second, is the common sense idea of a critic as an evaluator of an object, whether it be a work of art or a system for scientific discovery ("Oxford English Dictionary," n.d.). Third, is the philosophical idea of critical evaluation and theory. Philosophy has a long tradition, stretching from Descartes to today, of looking for the necessary components of ideas and knowledge. There is also a specific usage of critical theory that originated among German philosophers at the start of the twentieth century. Horkheimer distinguished between traditional and critical theory by saying the the latter seeks human emancipation. Habermas is considered to be a major member of the Frankfurt School which propagated many of the ideas of 'critical theory' by combining philosophy, social science, and Marxist thought (Bronner, 2011).

So the work of this section is to introduce two thinkers, Dewey and Habemas, who may be used to critique citizen science. To understand the direction of that critique requires some background knowledge which is provided in this section of the dissertation.

The background introduces Dewey and his context within pragmatism. Pragmatism is genealogically connected to the social worlds discussion from earlier in this chapter through the work of George Herbert Mead. Dewey is valuable at this point because he presents a picture of inquiry which can be connected to public interests.

Habermas is valuable because he also connects inquiry and the public through the development of a theory of communicative action. But his theory is developed out of a background that critiques scientism as a preferred method for the discovery of knowledge about the social world. Dewey wrote at a time when the success of

science was widely accepted. Habermas wrote at a time when this success was being questioned in both the academy and the social world. The questioning of science influences the later development of participatory-engagement movements such as citizen science. A fuller trajectory of this development will be reconstructed in the discussion chapter of this dissertation.

3.2.1 Dewey and Democracy

Pragmatism is a school of philosophy that began in the United States during the late nineteenth century. The major figures in the movement were Charles Sanders Peirce, William James, and John Dewey. Other people, like George Herbert Mead and Oliver Wendell Holmes, transferred pragmatism into new fields such as the social sciences and the law. Pragmatism remained a significant feature of American philosophy into the middle decades of the twentieth century. After World War Two European emigre philosophers brought a new influx of ideas from the Frankfurt school and logical positivism which led to the gradual decline of pragmatism as an important school of philosophical thought. Since then pragmatism has been elaborated by a smaller number of contemporary philosophers such as Richard Rorty, Hilary Putnam, and Richard Bernstein (Hookway, 2010; Menand, 1997).

The main concern of the early pragmatists was the rejection of the Cartesian heritage of philosophy which contributed to a number of pernicious distinctions that were damaging to future inquiry. Peirce argued that Cartesianism was mistaken to begin with universal doubt; instead of doubting everything "we must begin with all

the prejudices which we actually have when we enter upon the study of philosophy" (Menand, 1997, p. 4). He also argued against using the consciousness of the individual as the ultimate test for certainty. Modern science showed that a community of practitioners and investigators could reach agreement about the constitution of the world (Menand, 1997, p. 5) The conclusion of these arguments led Peirce to formulate a pragmatic maxim that ideas should be evaluated by "Consider[ing] what effects, which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of those effects is the whole of our conception of the object." (Hookway, 2010, p. 7). The key point in this maxim was the concern with 'practical bearings.' Practical concerns suggest that part of the process of philosophy is examination of the effect our actions and ideas have in the world.

James described pragmatism as an attempt to reconcile two conflicting points of view which will sound familiar to those who have followed the paradigm debates of the late twentieth century. One side was the 'tough minded' approach of the ardent empiricist who appeals to the facts in order to resolve disagreement. The 'tender minded' is more idealistic and less inclined to appeal to empirical facts and more sympathetic to internal ideals and meanings. For James the conflict between science, morality, and religion was a result of the competition between tough- and tender-minded approaches to philosophy (Hookway, 2010). Today the social scientific dispute between positivism and interpretivism is very similar to the divide between tough- and tender-minded. Positivism believes science is the one correct way to

discover the Truth about the world. Interpretivists are skeptical of these claims and focused on the investigation of meaning or understanding (Benton & Craib, 2011).

Dewey is valuable to the current dissertation for two major contributions. First, is his theory of inquiry which describes an important continuum between common-sense and expert scientific judgment. Second, is his description of the public, which has been partially covered in chapter 2. His conception of the public will be connected to his theory of inquiry in the following sections.

The Theory of Inquiry

Dewey continued the pragmatic program by elaborating a theory of human inquiry that recognized the influence of science without separating it from other forms of inquiry. For Dewey human inquiry was all of a piece; there was no distinct barrier between science and other forms of human inquiry. According to Dewey there are five stages which form the logic of inquiry. The first stage is the antecedent condition or indeteminate situation. We encounter situations in the world that are uncertain and unclear, it is the nature of the situation that is doubtful not some aspect of our understanding.

> Personal states of doubt that are not evoked by and are not relative to some existential situation are pathological . . . situations that are disturbed and troubled, confused or obscure, cannot be straightened out, cleared up and put in order, by manipulation of our personal states of mind. (Dewey, 1981, p. 227)

Dewey blurs a number of philosophical distinctions in this formulation of the start of inquiry. For one thing he accepts Peirce's critique of Cartesian individual doubt. He also emphasizes the connection between action and theory by refusing to separate doubt from the conditions where it occurs. The next step forward in the process of inquiry is recognition of the problem.

> To find out what the problem and problems are which a problematic situation presents to be inquired into, is to be well along in inquiry. To mistake the problem involved is to cause subsequent inquiry to be irrelevant or to go astray. Without a problem, there is blind groping in the dark. The way in which a problem is conceived decides what specific suggestions are entertained and which are dismissed; what data are selected and which rejected; it is the criterion for relevancy and irrelevancy of hypotheses and conceptual structures . . . a problem that does not grow out of an actual situation is to start on a course of dead work, nonetheless dead because the work is 'busy work.' Problems that are self-set are mere excuses for seeming to do something intellectual, something that has the semblance but not the substance of scientific activity. (Dewey, 1981, pp. 229-230)

Two important ideas are present in this passage. The first is the importance of context. One of the most challenged aspects of the positivist view of science is the belief that inquiry can be separated from the context in which it occurs. The

argument that science can and should be value-free is one example of this viewpoint. Dewey argues that the conception of a problem, even in the early stages of inquiry, is a crucial part to the whole process. If a problem is misconceived then the results will be mistaken. The second point to note in this passage is the further strengthening of the connection between social and the scientific. Problems that are proposed in isolation, by the individual self, may resemble scientific inquiry but are not actually part of it.

The third stage of inquiry is the development of a problem-solution. Ideas about the situation come from further investigation of the situation. These ideas become possibilities for future action, anticipations of continued activity. Ideas are evaluated based on their actual functions in the situation at hand, some ideas are valuable because they improve our understanding of the situation while other ideas are rejected because they do not contribute to understanding. The fourth stage is reasoning about the ideas that are proposed during the development of the problem-solution in stage three. At this point we begin to develop hypotheses that may be tested by experience or experiment. The final stage of inquiry is action, or the operational implications of the facts-meaning that have been determined by inquiry. The facts determined during the course of inquiry interact with each other and gradually lead to a more determinate situation. It is the interaction of these facts with new observations that 'proves' their relevance and correctness for the situation at hand. But these facts are still provisional and may be called into question by new situations (Dewey, 1981).

The key point Dewey makes is that the demarcation between science and other types of inquiry is porous. Both Kuhn and Popper can be used to argue that there are strict separations between science and other human activities. The incommensurability argument of Kuhn can be appropriated to defend the border between different eras and types of science, just as the falsification criteria proposed by Popper can be used to police the same borders. But defending these borders too vigorously can close science off from new sources of knowledge and opportunity. One of those opportunities is citizen science.

Inquiry and the Public

According to Dewey there is a direct connection between inquiry and the existence and maintenance of a public. According to Dewey a public arises in response to the indirect consequences of action by others. A public becomes necessary when individuals act in a way that affects others. But in order for this public to come into existence there must be open access to all information and consequences which concern it. "There can be no public without full publicity in respect to all consequences which concern it. Whatever obstructs and restricts publicity, limits and distorts public opinion and checks and distorts thinking on social affairs." (Dewey, 2008, p. 339) Lack of publicity also limits the possibility of social inquiry by limiting the free exchange of information.

> Opinions and beliefs concerning the public presuppose effective and organized inquiry. Unless there are methods for detecting the energies

> which are at work and tracing them through an intricate network of interactions to their consequences, what passes as public opinion will be "opinion" in its derogatory sense rather than truly public, no matter how widespread the opinion is. (Dewey, 2008, p. 346)

So the public arises in response to the consequences of an action and inquiry arises in response to an indeterminate situation. Both arise together because the public needs information in order to reflectively understand itself. Social situations differ from the natural world because people are involved who can reflect on the situation and modify it as they see fit. Inquiry is necessary for this process of self-reflection. But inquiry can also be limited because of social factors. Obsequious reverence for institutions and the division of knowledge into separate institutions are two ways that inquiry is sometimes limited. Privacy and suppression of information can also limit public inquiry. News organizations have an important role to play in disseminating information to the public but are too often diverted by the sensational. Local communities and the networks of communication that they foster are also important to the continuance of social inquiry.

Experts, such as scientists, are an interesting example of inquiry that may be beyond the experience or understanding of many. The danger for experts is that their inquiries will be cut off from the rest of the public and become a specialized class. Dewey does not argue that everything needs to be understood by the public but rather the public necessarily must be included in the formation of policy.

> The essential need, in other words, is the improvement of the methods and conditions of debate, discussion, and persuasion. That is the problem of the public. We have asserted that the improvement depends essentially upon freeing and perfecting the processes of inquiry and of dissemination of their conclusions. Inquiry, indeed, is a work which devolves upon experts. But their expertness is not shown in framing and executing policies, but in discovering and making known the facts upon which the former depend. They are technical expert in the sense that scientific investigators and artists manifest expertise. It is not necessary that the many should have the knowledge and skill to carry on the needed investigations; what is required is that they have the ability to judge of the bearing of the knowledge supplied by others upon common concerns. (Dewey, 2008, p. 365)

3.2.2 Habermas and Communication

Jurgen Habermas is one of the most influential social theorists of the twentieth century. His contributions extend the developments of critical theory, a school of social thought that originated in 1920s Germany and attempted to address the problems of modernity and its relation to technology and science. Critical theorists noted with concern the growing influence of phenomenology, which claimed to determine the conditions of all human consciousness, and positivism, which proclaimed the preeminence of the natural sciences for understanding the social world. The result

was increasing alienation through the exploitation of labor and the reification of individuals removed from their contextual situation. It was a response to the triumph of mass production. World War Two accelerated their critique and led to a general questioning of the principles of rationality and democracy that had driven the Enlightenment. How could humanity praise rationality after the industrial horrors of Auschwitz and the Holocaust? After World War Two the major critical theorists, such as Horkheimer, Adorno, and Marcuse deepened their criticism of a mass media age that reduced human beings to cogs in the machine of capitalism (Bronner, 2011).

Habermas began his career by writing about the public sphere in the 1950s and later developing a complete theory of communicative action that attempted to show how modernity originated and how it could be improved at the same time. Like many of the critical theorists associated with the Frankfurt school Habermas was critical of rationalization and scientism. The massive successes of science and technology during the first half of the 20th century led to an overreach by positivist researchers who believed that science and rationalism were the only correct tool for understanding the world. One objective of Habermas' work during the 1960s and 1970s was to criticize the perceived triumph of positivism and to show how a critical stance, informed by Marx, Weber, and other social theorists, could be used to augment the Enlightenment project of furthering democratic ideals. His early work on the public sphere set the stage for a series of works that examined contemporary capitalist society and attempted to diagnose the sense of crisis that was pervasive in the social movements of the 1960s. Through the 1970s Habermas engaged with contemporary philosophy

of language to develop a theory of communicative action which he believed could be used to continue the critical tradition of human emancipation begun in the works of earlier members of the Frankfurt school (Outhwaite, 2009).

There are three reasons for using Habermas in this dissertation. First, his criticisms of technology and rationalization of the lifeworld represent some of the ideological arguments that led to calls for increased participation by the public in scientific decision making. In his responses to the student movements of the 1960s he helped to form the intellectual climate that led to the development of science and technology studies and the gradual erosion of the post-war belief in scientific autonomy. Second, his major theoretical work on communication presents a speech situation that can be used as a comparison to current interactions between professional scientists and citizen scientists. The theory of communicative action presents a situation which can be assessed and measured. Third, his work on the history of the public sphere will be used to develop the idea of the public and its relationship to science.

Engaging Rationality, Science, and Technology

Habermas is a critic of the disconnect between democratic decision-making and the rationalist aspirations for social order. Both of these are aspects of the Enlightenment project and are often found to be in contradiction. The rationalist aspirations lead to decision making by experts based on scientific evidence, while the democratic tendency promotes the power of the individual to influence decisions through voting

and representation (Evetts et al., 2006). Habermas began his critical consideration of positivism by examining the history of philosophical thought. His major work of the time, "Knowledge and Human Interests" (Habermas, 1971), traced the history of three approaches to human action and knowledge: technical, practical and emancipatory.

In "Technical Progress and the Social Life-World" Habermas discusses the historical context and problem of reconciling technology and the lifeworld. Technology and science cannot be immediately integrated into the social lifeworld because there is a difference between technical control and the "action-orienting self-understanding of groups" (Habermas, 2003, p. 531) Scientific knowledge, by itself, is inconsequential for the social world; quantum physics has no impact upon social relations. So mediation is needed for science to impact the everyday lifeworld, usually in the form of a technical advance that increases practical knowledge.

The two traditional ways to mediate science and the lifeworld were technical exploitation and education. Exploitation meant the application of science to the practical problems of the lifeworld; technology was used to improve the practical performance of craft knowledge. Education acquainted someone with theory that could be used to form normative understanding.

> Understanding the cosmos as a whole yields norms of individual human behavior, and it is through the actions of the philosophically educated that theory assumes a positive form. This was the only relation of theory

> to practice incorporated in the traditional idea of university education. (Habermas, 2003, p. 532)

Habermas describes three categories of inquiry: technical, practical, and emancipatory. Technical inquiry is focused on "information that expands our power of technical control ... over objectified processes." (Habermas, 1971, p. 309) Such advances, using experimental methods, lead to changes in the world of work. Practical inquiry is interpretive and "make[s] possible the orientation of action within common traditions." (p. 313) The activity takes place in the realm of language and is oriented toward possible consensus and group understanding. Emancipatory inquiry is critical and self-reflective. The result is "analyses that free consciousness from its dependence upon hypostatized powers." (p. 313) Theory is a main source for emancipatory inquiry. "The only knowledge that can truly orient action is knowledge that frees itself from mere human interests and is based on Ideas - in other words, knowledge that has taken a theoretical attitude." (p. 310)

The problem with the current, modern situation is that theory can become action in todays economy without any regard to the emancipatory questions that must be raised in order for people to reflect upon their conditions.

> Today, research practices are coupled with technical conversion and economic exploitation, and production and administration in the industrial system of labor generate feedback for science. The application of science in technology and the feedback of technical progress to research have become

> the substance of the world of work . . . Today, theories can become technical power while remaining unpractical, that is, without being expressly oriented to the interaction of a community of human beings. Of course, the science now transmit a specific capacity: but the capacity for control, which they teach, is not the same capacity for life and action that was to be expected of the scientifically educated and cultivated. (Habermas, 2003, p. 532)

The connection between technology and exploitation has become so close that transfer seems to occur without much thought. One response is Marxian - the ideal communist state that rationally and democratically controls technology - the other response is technical determinism that just surrenders to the development of new technologies. Habermas rejects both poles and calls for a unification/dialectic of potential and will that allows discussion of technology without domination.

Science and technology studies became a significant discipline within the social sciences during the 1970s just after Habermas delineated his critique of technological rationalism. His work and the work of other scholars, many of whom were involved in the strong program for the sociology of knowledge, provided the groundwork for challenging the image of science as an autonomous discipline free from the constraints of values or society. These challenges in turn fueled the public understanding of science movement which began in Britain during the 1980s and attempted to address a perceived understanding gap between the public and science (Gregory & Miller, 1998).

Citizen science is an outgrowth of the public understanding of science movement that continues to influence science governance to the current day.

Communicative Action

Habermas was dissatisfied with his philosophical critique of positivism because he felt it was still stuck within the assumptions of a philosophy of the subject. The only way to truly address the challenges of modernization and rationality was to approach the problem from an intersubjective point of view, to look at the relations between subjects not just the internal thoughts of a subject. The result of this shift was a turn by Habermas to focus on the philosophy of communication and language because those were the media through which intersubjective understanding was created (Thomassen, 2010). Over the course of a decade Habermas worked on these issues and ultimately produced the two volume "Theory of Communicative Action" (Habermas, 1984).

The theory of communicative action was an attempt to reconstruct human actions in an intersubjective context mediated by human language. Communicative action is focused on the achievement of mutual consensus which is used to coordinate human activity and support human development. Social action can be divided into different purposes. One of those is strategic action which is aimed toward the successful achievement of some goal. Communicative action is aimed toward understanding.

> For the communicative model of action, language is relevant only from the pragmatic viewpoint that speakers, in employing sentences with an orientation to reaching understanding, take up relations to the

> world, not only directly as in teleological, normatively regulated, or dramaturgical action, but in a reflective way. Speakers integrate the three formal world-concepts . . . into a system and presuppose this system in common as a framework of interpretation within which they can reach an understanding . . . Reaching an understanding functions as a mechanism for coordinating actions only through the participants in interaction coming to an agreement concerning the claimed validity of their utterances, that is, through intersubjectively recognizing the validity claims they reciprocally raise. (Habermas, 1984, p. v1.99)

The worlds he refers to in this quote are the external objective, social normative, and subjective worlds. These worlds have corresponding validity claims. For the external objective world validity is based on the truth of a statement. For the socil normative world validity is a matter of rightness with respect to the normative world. For the subjective world validity is a match to the intention of the speakers internal world.

> The concept of communicative action singles out above all two aspects of this situation management: the teleological aspect of realizing one's aims and the communicative action of interpreting a situation and arriving at some agreement. In communicative action participants pursue their plans cooperatively on the basis of a shared definition of the situation . . . success achieved by teleological action and the consensus brought about by acts of

> reaching understudying are the criteria for whether a situation has been dealt with successfully or not. A situation represents a segment of the lifeworld delimited in relation to a theme. A theme comes up in connection with the interests and aims of at least one participant; it circumscribes a domain of relevance of thematized elements of the situation, and it is accentuated by the plans that participants draw up on the basis of their interpretation of the situation, in order to realize their ends. It is constitutive for communicative action that participants carry out their plans cooperatively in an action defined in common. (Habermas, 1984, p. v2.127)

A number of concepts introduced in this passage parallel similar concepts that have been introduced in the discussions of social world theory and communication framing and situational analysis. Themes help to form situations in a similar matter to how frames form the understanding of communications. The passage also introduces the idea of a lifeworld, a topic which Habermas borrows from phenomenology. A lifeworld is the background horizon that forms the basis for communicative action, it represents the assumed social grounding of intersubjective communication.

> Under the functional aspect of mutual understanding, communicative action serves to transmit and renew cultural knowledge; under the aspect of coordinating action, it serves social integration and the establishment of solidarity; finally under the aspect of socialization, communicative action

> serves the formation of personal identities. The symbolic structures of the lifeworld are reproduced by way of the continuation of valid knowledge, stabilization of group solidarity, and socialization of responsible actors. (Habermas, 1984, p. v2.137)

But communicative action is not the only model of action open to human beings. People can also act teleologically, normatively, and dramaturgically. The models of action parallel the different worlds in which humans act: the objective, the social, and the subjective. Communicative action is aimed towards mutual understanding and can access all three of these worlds which means it can be judged based on criteria for truth, rightness, and authenticity.

Modern capitalist society tends toward crisis when the lifeworld is colonized by the system. Internal and external differentiation of the lifeworld happen at the same time. Internally the lifeworld is divided into separate components of culture, society and personality. External systems are ways of transferring actions into permanent rational modes which take the form of steering media. The two most important forms of steering media are money and power. Action which was previously mediated through the lifeworld and communication aimed at mutual understanding is systematically transferred into non-linguistic steering media which cannot be negotiated in the same way as intersubjective communication. This is the colonization of the lifeworld by the system.

> The transfer of action coordination from language over to steering media means an uncoupling of interaction from lifeworld contexts. Media such as money and power attach to empirical ties; they encode a purposive-rational attitude toward calculable amounts of value and make it possible to exert generalized, strategic influence on the decisions of other participants while bypassing processes of consensus-oriented communication . . . Societal subsystems differentiated out via media of this kind can make themselves independent out of the lifeworld, which gets shunted aside into the system environment. Hence the transfer of action over to steering media appears from the lifeworld perspective both as reducing the costs and risks of communication and as conditioning decisions in expanded spheres of contingency - and thus, in this sense, as a technicizing of the lifeworld. (Habermas, 1984, p. v2.183)

This is scientism and rationalization of the lifeworld run amok. Habermas differs from the other social critics of technology such as Ellul, Marcuse, and Mumford because he still accepts a role for rational communication that is aimed at mutual understanding and non-coercive. Rationality can still be used as a tool for Enlightenment as long as it is used respectfully. Action can either be communicative or strategic. The former is preferred because it respects the rights of others and the process of communicative action. The latter can be used for good or bad. It can be used to advance our understanding of the world but its incursion into the

lifeworld must be carefully monitored. And when it is used to deceive or to achieve an advantage for one group over another it must be confronted by new instances of communicative action.

3.3 Guiding Questions

The theoretical discussion and sensitizing concepts discussed in this and the previous chapters present an opportunity to propose some evaluative criteria for citizen science. The current section will review some of the concepts introduced so far and attempt to formulate a set of guiding questions for critical evaluation of citizen science. These items can then be searched for in the data collected in order to detect trends.

The list below describes some potential changes in science and public relations which might be observed because of citizen science.

- Altering the conception of science. Section 2.1 discusses two definitions of science. One is as a method for exploring nature, the other is as a social process. A shift toward the latter indicates a change in the relationship between science and the public. There is evidence for a historical shift in attitudes/interactions with science in the 20th century, a move from scientific autonomy to increased participation (Lengwiler, 2008; Lewenstein, 1992). Such shifts also open up the public conception of science, moving away from science as a pure method toward science as a hybrid knowledge system (Bucchi & Neresini, 2008).

- Involving the public in science. There are philosophical reasons to increase the involvement of the public in science (Douglas, 2003) as well as practical reasons (Bonney et al., 2009; Silvertown, 2009). Democratic citizenship arguments can be made that the public has a right to be involved in technological decision making (Frankenfeld, 1992). Citizen science contributes to public participation at a number of levels, ranging from the contributory to the co-created (Bonney et al., 2009). Evidence for increased public participation would also be evidence for changes in the relationship between public and science. The potential methods and measures for this involvement are very diverse (Rowe & Frewer, 2005).

- Determining the goals for science based on public participation. The PEST (public engagement in science and technology) movement is one example of how the public may become increasingly important to determining the goals of scientific research. Other activist groups, in medicine and the environment, also demonstrate public intervention in scientific goal setting (Bucchi & Neresini, 2008). Emergent forms of citizen science, often driven by local activists, is an example of how science is being repurposed with goals that are potentially different from business or government sponsored research (Ottinger, 2010; Wilderman, 2007). Co-created citizen science projects which increase the degree and quality of participation by volunteers are leading the way toward incorporating public goals into the scientific research process (Shirk et al., 2012).

- Shifting the boundaries between amateurs and professionals. Boundary work has been established as a key rhetorical tool used by scientists and other professionals to defend their domains (Abbott, 1988; Gieryn, 1999). The boundary between professional and amateur also fits into a larger system of interactions between the public-amateur-professional roles (Stebbins, 1982b). The constitution of these categories can shift because of historical and sociological changes, some of which may be the result of deliberate action by agents interacting with the system or the result of structural changes in the economic or social world. Citizen science can contribute to these changes in the short- and long-term. Short-term changes to the boundaries may be the result of public activism from outside of the scientific establishment (Ottinger, 2010) or else from internal changes by scientists who recognize a need for change. Long-term changes may include changes in publishing infrastructures, knowledge reward systems, and cultural norms.

- Altering the boundary between expert and novice. Science and technology scholars have already identified shifts in this boundary (Collins & R. Evans, 2002). From a psychological perspective expertise is measured through competence or ability (Ericsson et al., 2006), but being an expert is also a social status (Evetts et al., 2006). There is some evidence from previous studies that participation in a citizen science project improves the individual skills and knowledge of the participant (Bonney et al., 2009). So that is one way

of detecting changes in the expert/novice boundary by observing an increase in expert knowledge among volunteers. Observing changes in the social status or relations of experts may be more difficult. Artifacts left by people, such as newspaper articles or press releases, may be one source of evidence for changing social relations. Another source may be with personal behaviors observed through extended observation. The main evidence addressed in this dissertation is discourse based - changes in language/frames used in newspaper articles and reports/answers provided in interview settings.

- Changes in professional networks and organizations. Organizations and institutions are ways for human beings to share activity. An activity is repeated by an individual until it becomes a habit, and then those habits are reciprocally shared and become typified as an institution (Berger & Luckmann, 1966). Social worlds are an early stage on the road to forming more permanent institutional structures (Strauss, 1978). A social world begins with individual identification with a particular activity, different levels of participation become codified forming a spectrum between outsiders and insiders (Unruh, 1979). The institutionalization of these social roles can be treated as evidence for changes in the relationship between group members and the rest of the world. Citizen science is currently undergoing some of these changes as institutions develop out of the already existing social world.

One of Dewey's major contributions to the current discussion is his notion of a public being a response to a particular situation formed by the actions of other people. The key question is how a public is formed? What is it responding to? Who participates in the response?

Another Deweyan point is the importance of access to knowledge and inquiry. For a public to be successful it must have full access to the knowledge that is produced through the process of inquiry. Misleading or mistaken information which reaches the public is detrimental because it prevents reflective decision making. What is the access of the public to the information and knowledge produced by citizen science? Is the knowledge produced by citizen science accurate and worthy of public attention?

Habermas suggests some additional questions as well. For Habermas one of the key transitions is between strategic and communicative action. An overabundance of strategic action contributes to the colonization of the lifeworld. Communicative action in turn requires respect for others, a willingness to listen rationally to an argument, and aiming toward mutual understanding. Does citizen science foster a forum for mutual understanding? Are the actions of scientists and volunteers strategic or communicative?

Chapter 4

Methods

4.1 Research Design

The research questions posed in this study require a heterogenous approach to answer them because they span a wide variety of activities which can be manifested in multiple ways. Frames, as discussed earlier, are often analyzed by looking at content from the news media. Mass media lends itself to such analysis because it addresses a large audience and compresses messages into smaller pieces using metaphors and other rhetorical techniques in order to reach a large audience. But identifying the frames used in the discourse around citizen science is not the only research question to be answered. An understanding of the creation of frames and their transfer between different actors is also being sought.

Looking at the creation of frames brings in multiple actors who cross multiple social worlds. Each actor has a role to play in the development of a frame

and the attendant communication strategies. Including the actors and the social worlds/arenas involved in communication about citizen science opens up the study of frames beyond basic content analysis. The context/situation becomes an important unit of analysis so that the transfer of frames between different actors can be traced.

An additional challenge is posed when trying to understand how or whether citizen science is affecting the relationship between science and the public. Additional concepts need to be considered, some of which have been introduced in chapter 2, to sensitize the theoretical and methodological gaze through which the problem is approached (Clarke, 2005, p. 77). The analysis of the situation in which citizen science has arisen becomes even more important when seeking answers to this final research question.

A method for answering such questions needs to be able to meet a number of criteria. First, it needs to be able to incorporate disparate data sources such as interviews, media content, and press releases. Second, it needs to be broad in scope to cover the multitude of actors involved in the process of framing citizen science. Third, it needs to be theoretically adaptable to the different concepts and theories being used in the current study. Situational analysis fulfills all of these criteria (Clarke, 2005). SA was developed over the past two decades as an extension of grounded theory. Its genealogy and some of its key precepts were introduced in chapter 3 in the discussion of social worlds.

Both SA and grounded theory can be considered forms of qualitative inquiry. Qualitative inquiry can be characterized by a number of attributes: a natural

(non-laboratory) setting, the researcher as key instrument, multiple sources of data, inductive data analysis, concern with participants' meaning, emergent design, interpretive analysis, and a holistic account of phenomenon (Creswell, 2008, pp. 175-6). All of these are present in the current study. A natural setting was chosen in order to capture the creation process of frames which occur in the interactions between actors involved in citizen science. The distributed nature of citizen science, with projects scattered across the world, precluded a laboratory design because the cost of bringing all the actors together would be prohibitive. The researcher has a long interest in how the internet mediates creativity and knowledge creation, citizen science being one recent example. Participant meaning is important because frames emerge from individual beliefs and choices about citizen science. Choosing to be involved with a citizen science project or choosing to work as a writer lead to different meanings which need to be negotiated through discourse across boundaries. An inductive approach to analysis was chosen because citizen science, at least as a linguistic term, is relatively new and has not developed enough for deductive theoretical testing.

Qualitative inquiry also lends itself to the exploration of emergent social activities. Citizen science, or at least this current incarnation of it, depends on numerous emerging technologies. The internet, social media, GPS, smartphones, and other types of technology contributed to the current surge in citizen science. A qualitative approach can maintain a broad focus and incorporate targeted data at the same time.

4.1.1 Situational Analysis

The primary unit of analysis in situational analysis is the situation itself. SA takes a broad approach to the situation and makes few theoretical assumptions about a site. It is committed to many of the theoretical ideas found in social worlds theory and symbolic interactionism. It also explicitly pays attention to postmodern concerns about power, knowledge, and discourse (Clarke, 2005, p. 77). However the particular theorists used to analyze these structures is open to the choice of the research. Thus the current study uses John Dewey and Jurgen Habermas as the primary theoreticians to critically open up a discussion of citizen science.

One of the key metaphors in SA is cartography. The goal is to map out the situation in a variety of ways throughout the research process. Mapping is a visual way to represent complex information and suggests a topographical relationship between different actors involved in a situation. It parallels the ideas of social worlds theory with its focus on different actors who are involved at different levels of function and participation within a social world (Clarke, 2005).

SA describes three different types of maps that can be used during the analytical process of exploring data which can be seen in table 4.1 (Clarke, 2005, p. 86).

The situation being analyzed in the current study is the communication arena between citizen science projects and members of the public. The arena is filled with multiple actors, multiple goals, and multiple documents and artifacts. A partial list of the actors involved includes scientists, project managers, public information

Table 4.1: Maps Used in Situational Analysis

Type of Map	Definition
Situational maps	as strategies for articulating the elements in the situation and examining relationships among them.
Social world/arena maps	as cartographies of collective commitments, relations and sites of action.
Positional maps	as simplification strategies for plotting positions articulated and not articulated in discourses.

officers, and journalist/writers. A potential list of documents that could be used as evidence includes scientific papers, press releases, newspaper articles, blog posts, web stories, project websites, and project directories. Both lists were identified during the proposal stage.

Like grounded theory, SA is engaged in a constant comparative process between analytical outcomes and data gathering. Data is analyzed while it is being gathered and the analysis is used to purposefully select data for future collection. The result is a project that follows curiosity and interesting concepts as they arise, instead of having a predetermined analytical plan.

SA does not make any prescriptions about the type of data to be collected during a research project. The current project uses a number of typical types of data found in qualitative studies in general: observations of people working within the citizen science community, interviews with actors involved in citizen science, and documents produced by or for those actors (Creswell, 2008).

4.2 Data Collection and Analysis

The data for this dissertation can be divided into four main sources: bibliographic, naturalistic observation, journalistic and public relations content, and open-ended interviews. Table 4.2 describes the type of data, its source, the amount, and the analysis for each data type used in this dissertation. The main unit of analysis is the situation that surrounds public communication in citizen science projects. Thus data was collected based on the role of the people who produce the data and their involvement in the citizen science arena. Four main roles were identified through conceptual analysis of citizen science. The first were scientists/researchers who are naturally expected to be involved in any scientific endeavor. The second were project staff. The third were journalists/writers who produce content about citizen science. The fourth were public information officers who write press releases about citizen science projects. These four roles were identified in order to encompass as much as possible of the communication process in citizen science projects. Volunteers were left out of this study because of time constraints and theoretical focus on frame formation and creation which was believed to be controlled by elites involved in citizen science.

4.2.1 Bibliographic

Bibliographic data was obtained from two sources: Scopus and Web of Knowledge. Scopus is a literature index and aggregator developed by Elsevier. Web of Knowledge is another aggregator/index developed by Thomson-Reuters. Both databases allow

Table 4.2: Data Collected

Data Type	Source	Amount	Analysis
Bibliographic	Scopus and Web of Knowledge	568 Records Through 2013	Trend graphs of articles per year
Observation	DataONE Meetings and Web Email Lists	Over 3 years	Notes kept in Evernote
Content	Lexis-Nexis and Eurkealert	Newspapers 6 months N=166, Press Releases 3 months N=13	Articles and PR coded in Nvivo
Interviews	Recruitment Email, Personal Contacts	4 Researchers 2 Staff 4 Writiers	Transcribed and then coded in Nvivo

for phrase searches, such as "citizen science". Searches were conducted in February 2014 to collect articles that had been published through 2013.

References were downloaded during the literature review and used for some basic analysis of publishing trends in citizen science. A report of the results is found in chapter 5. The literature also informed conclusions about the structure of citizen science and the goals of researchers.

4.2.2 Observation

Observation is one of the key parts of social science research but also a difficult activity to define concisely. Philosophers will tell you that all of our lives are built on observations of the world. But social scientists strive to be specific about observation because that specificity lends empirical support to the arguments being made.

A common way to describe observation is to modify the amount of participation by the researcher in whatever arena is being studied. Thus there is a distinction

made between different levels of participation, ranging from complete participation, participant-observer, observer-participant, and direct observer. A researcher moves along this spectrum of participation in order to position herself with respect to a body of colleagues, a discipline, and the subjects of a study. Some disciplines, such as anthropology, demand a significant level of participation by the researcher in the community that is being studied. Anthropologists call this ethnographic research. Other disciplines, such as communication and information science, borrow concepts and practices from disciplines such as anthropology, which leads to formulations about 'ethnographically inspired' research methods.

The most significant observations for the current research project were made during October 2013 at the DataONE all-hands meeting. DataONE is a large data curation infrastructure project sponsored by the National Science Foundation. It is composed of working groups which are made up of 10-15 people who work together on a specific topic relevant to the goals of DataONE. Since its inception in 2009, DataONE has had a citizen science working group, which was later renamed to PPSR (Public Participation in Scientific Research). Observations of the PPSR working group were gathered during the October meeting and written up as field notes. Discussions in an online email listserv were also observed during the fall of 2013 and spring of 2014. The data from both of these observations contributes to the description of the social world of citizen science.

4.2.3 Content Analysis

The analysis of public artifacts is a crucial part of understanding communicative behavior. A large portion of our experience and knowledge of the world comes from information received through communication channels such as newspapers, weblogs, and websites. Studying material and textual artifacts of citizen science increases the range of communication and information behaviors observed. For many citizen science volunteers the written and visual evidence of a website may be the only communication they receive from a project. A written record can convey different messages and use different frames than a verbal utterance. Written and visual material may also persist longer than a verbal exchange, and display an idealized portrait of citizen science. Comparing these portraits to evidence gained from interviews will explain how, and for what purpose, the frames are created. The key is to develop a context for the artifacts examined, identify similarities and differences, and then compare the texts to the theories being used in this study (Hodder, 2000).

In Februrary 2014 a set of newspaper articles on citizen science were collected from the web database Lexis-Nexis. Lexis-Nexis was chosen because it collects articles from major English newspapers. All the articles that matched a phrased query for "citizen science" and that were published during the final 6 months of 2013 were downloaded. The initial download contained 266 articles. An initial coding of the articles was done to identify possible interview contacts by searching for contact information such as email address, telephone numbers, or Twitter handles. Data about the title of articles,

their source, geographic location, and date of publication were also collected during this first round of coding. Duplicates and press releases were identified and discarded from the final data set. A number of non-relevant articles, such as co-occurance of the words citizen and science between two sentences, were also captured by the database search and eliminated from the final data set. After cleaning the data there were 166 newspaper and media articles remaining.

The cleaned data was loaded into NVivo for coding and analysis. Each article was examined for a series of items, including news framing, article genre, quotations, people mentioned, definitions of citizen science, and affiliate or sponsoring organizations. A full coding frame is presented in appendix A.3.

Press releases were collected using Eurkealert, a service managed by the American Association for the Advancement of Science. A query phrase, "citizen science", was used to identify potentially relevant press releases posted from December 15, 2013 to February 15, 2014. The more recent time frame was chosen in order to identify public information officers who would likely remember the incident because of its recency. Twenty press releases were returned by the query engine and were examined for relevance, leading to a final data set of 11 press releases. These were loaded into the same NVivo database and coded in the same manner as the newspaper stories. Data from newspaper articles are referenced with the abbreviation LN and an identification number. Press releases are referenced with the abbreviation PR and an identification number.

4.2.4 Interviews

The interviews conducted for this study were open-ended and contained between 20-30 questions. An interview guide is attached as an appendix A.1. Questions were designed to elicit answers about the first encounters of participants with citizen science, their current involvement in citizen science, and their opinions about the relationship of citizen science to science and the public. Probing questions were asked to gather more detail about the communication among different groups of people involved in citizen science: scientists, project administrators, public information officers, funders, other researchers, administrators, journalists, and volunteers. Interview questions were based on a combination of the literature, qualitative research recommendations, and personal experience with the field (Charmaz, 2006; Corbin & Strauss, 2008; McCracken, 1988)

Interview questions were also altered based on the backgrounds of the participants. Some participants, such as the journalists and public information officers, had little to no experience with citizen science so questions were modified to accommodate their experience levels, leaving out some of the more in-depth and personal experience questions to focus on questions about how they had encountered the term 'citizen science' and why the chose to use it in their writing. They were also asked more general questions about the relationship between science and society. The interviews lasted between 20-50 minutes depending on the amount of history of the subjects and the detail with which they answered the questions. For some interviews additional

questions were asked to probe for more details about the subjects experiences with citizen science (Corbin & Strauss, 2008).

Participants were purposefully recruited through a variety of sources that were identified during the initial design of the project. First, the staff at scistarter.org, one of the key website directories identified at the proposal stage were invited to participate in the interviews and to distribute the recruitment message. Second, invtations were sent to people likely to be involved in communication roles identified during observations of DataONE and email lists. The interview subjects contacted through these channels were mainly citizen science researchers and project staff.

Journalists and public information officers were recruited through the content analysis data that was collected for the project. Newspaper articles, web stories, and press releases were collected from various sources for textual analysis. Many of these sources contained public contact information such as email addresses, phone numbers, and Twitter usernames. Out of 166 content items found in Lexis-Nexis public contact information could be discovered for about 28 items. An additional 13 contacts were identified through the press releases collected from Eurkealert. Recruiting emails were sent out to this list and followed up with phone calls or Twitter messages, where such information was available.

In total 10 interviews were conducted. Four interviews with researchers involved in citizen science projects, two with project staff, and four with writer/journalists reporting about citizen science. The goal was to have a spectrum of people involved in citizen science communication roles. Interviews were transcribed and then loaded

into NVivo for analysis. Data from interviews is references with an abbreviation based on the role of the interviwee (R=researcher, S=staff, W=writer or journalist) and an unique identification number.

4.2.5 Credibility and Ethics

One criticism of naturalistic inquiry is the lack of evaluative standards such as validity, reliability, and objectivity found in positivistic inquiry traditions. Each of these standards can be defined precisely using statistical methods, especially in the natural sciences. Many social scientists borrow the same criteria for evaluating their own disciplines. The paradigm/qualitative battles of the 1970s and 1980s led to establishment of quality criteria for naturalistic research (Guba, 1981, 1990)

Many evaluators follow Guba in using 4 criteria for judging the quality of naturalistic research: credibility, transferability, dependability, and confirmability (Barker, 2003; Shenton & Hay-Gibson, 2009). The outcome of meeting these criteria is research that is plausible, context-relevant, stable, and investigator-free. There are multiple ways of achieving quality for each of the criteria proposed by Guba and other commenters on naturalistic research.

The following table shows some of the ways that this dissertation attempts to meet these criteria.

The research proposal was submitted for approval to the Institutional Review Board at the University of Tennessee. It was approved on December 4, 2013.

Table 4.3: Credibilty for Naturalistic Inquiry

Quality Criterion	Standard	Dissertation
Credibility	Adoption of well-recognized research method	Use of Situational Analysis
	Early familiarity with culture of participating institutions	Prolonged engagement extending back to 2008, deepened by experience with D1
	Iterative questioning in data collection dialogs	Questions were modified to reflect previous responses and to gather richer data.
	Negative case analysis	Contradictory or unexpected results were reported.
	Reflective commentary	Used throughout methods section
	Member checks	Interview transcripts were sent back to interview subjects for review
	Examination of previous research to frame findings	See literature review, and theory chapters
Transferability	Background data provided to give context of situation	See discussion of social worlds and history of citizen science
	Use of theoretical/purposive sampling	Interview subjects were chosen based on their role in the communication process for citizen science
Dependability	In-depth description of methods used	Described in methods section
	Overlap methods	both interviews and document content analysis.
	Audit trail	ongoing set of notes were kept throughout the research process.
Confirmability	Admission of researcher beliefs and assumptions.	Throughout dissertation
	Recognition of shortcomings in study	See conclusion

Chapter 5

Results

5.1 Framing Citizen Science

5.1.1 Frames

Previous research on framing in science communication established the existence of a set of common frames used for many science articles written for the mass media. The eight frames synthesized from previous communication research were outlined in table 3.1. Content collected from newspaper sources and press releases was analyzed for the presence or absence of these same frames. Using a set of established frames has advantages. It overcomes a common complaint among communication frame researchers of a lack of agreement upon the content of frames. Using a preexisting set of frames for the current study also widens the scope of the results beyond the specific community of citizen science to apply to science communication in general. Finally,

Table 5.1: Frames Found in Newspaper Articles

Name of Frame	Count of Articles Coded	Percentage of Articles Coded
Conflict-Strategy	1	0.6
Econ Dev Competition	4	2.4
Middle Way	0	0
Morality Ethics	4	2.4
Public Accountability	7	4.2
Runaway Science	0	0
Social Progress	13	7.8
Uncertainty	5	3.0

a preexisting set of frames also helps to show potential changes in the relationship between the public and science.

The results for this research question were unexpected. Theoretically one would expect for most, if not all, documents analyzed to fall into one of the frames described by previous research into science communication but the results for these documents on citizen science is quite different. The majority of items did not fit within the eight farmes found in previous science communication studies. Some frames such as social progress and public accountability were found in the current data set. These type of frames are not unexpected given the strong arguments made by the promoters of citizen science for the possibility of improved connections between public and science resulting from citizen science projects. But the small numbers still require some explanation. Some potential causes for this unexpected results are discussed in the remainder of this section.

Citizen science is a new topic for science communicators and science writers. The novelty of a topic may contribute to the failure of existing science communication frames to map to citizen science because of the uncertainty that results from new

developments. The absence of a pre-determined frame in the public arena means that journalists and writers are left without a standard narrative to fit the story of citizen science. Until now there were very few other elites who are guiding the story of citizen science in a particular direction. Some scientists, discussed in a later section, are trying to direct the conversation about citizen science toward educational impacts, but that frame is still emerging into public awarness.

One gap in the current research on news frames is the process of change and evolution for frames over time. Researchers agree that the origin of new frames is a research question that needs more investigation (Scheufele, 1999). Most research focuses on a comparison of different frames, usually through an experimental method, or a descriptive approach illustrating the existence of frames on a particular topic.

Non-controversial topics are framed differently from controversial topics. Most previous research on framing focuses on controversial issues such as climate change, evolution, stem cells, nanotechnology, nuclear power, or vaccinations (Gamson & Modigilani, 1989; Ho, Scheufele, & Corley, 2011). These topics are controversial from a scientific perspective because there are scientists who disagree with the conclusions of the majority of other scientists. Consensus on the topic may exist within the scientific community but there is no consensus on the topics in the mass media, and that is what framing studies are focused on.

Given the preponderance of potentially controversial scientific issues that have been studied using frames it seems likely that the controversy itself may effect the possible types of frames that were found. Some frame types identified in previous

studies, for example the conflict/debate frame, are specifically noting the presence of conflict among scientist over the issue that is being framed. Other frame types, such as social progress, are less likely to generate conflict or be the result of existing conflicts.

Science is framed as ordinary, part of the infrastructural background of daily life. Assume for a moment that citizen science is a non-controversial topic in the public arena, then how would we expect it to be described? Framing theory depends on the existence of metaphors and analogies in the minds of communicators. The metaphors we use determine part of our feelings and opinions about an issue. Frames also function as political objects for community building (Pan & Kozicki, 2001). Given this, it is possible that a non-controversial issue would be framed as part of an existing process or cultural institution. Metaphors, emotions, and cognitions attached to another cultural form are transferred from that form to citizen science. In the case of citizen science the topic is framed as a part of existing science. General science becomes the larger container for the specific example of citizen science. Citizen science is respected because science in general continues to be a well-respected part of life (Gregory & Miller, 1998). Being framed as just another part of the existing web of science makes citizen science a benign development, just an extension of existing cultural processes.

Another line of support for the ordinariness of science comes from infrastructural studies, an intellectual tradition with science and technology studies of looking at the basic technologies needed to run a society or an organization. One of the conclusions

of infrastructural studies is that infrastructure remains hidden during the course of everyday life. An infrastructure is only noticed when it breaks or malfunctions, throwing off the course of normal life (Bowker & Star, 1999). The electric grid is a good example, at least within the Western developed world. Most people expect the electric grid to function without much thought about the details of the system itself. When the switch is flipped power comes out. Other systems of modern life, such as drinking water and waste disposal, also function without our attention. My contention is that science is treated by many people, including writers and journalists, as part of techno-scientific background condition of modern life. Habermas reaches a similar conclusion in his discussion of rationalization and modernity. Techno-science is one of the major sources for further rationalization of behavior, and is integrated rapidly into daily life without significant reflection (Habermas, 2003).

The ordinariness of citizen science can be seen in some of the behaviors and comments of the people interviewed for this study. Two of the interview subjects mentioned the idea that citizen science functions as a label. A label is “a classifying phrase or name applied to a person or thing.” (“Oxford English Dictionary,” n.d.) A label is a form of typification (Berger & Luckmann, 1966). Labels are convenient ways of

A lack of match with previous studies or researchers. It is possible that the frames coded in this study could have been coded differently by another researcher. There were no tests for intercoder reliability conducted during this project. Reliability is usually considered a research standard for quantitative/rationalistic inquiry, not

qualitative/naturalistic (Guba, 1981). So the absence of such a measure is not conclusive.

Some of the non-coded articles that lacked any one of the preexisting codes could have been coded as examples of social progress or economic competitiveness by another researcher. Social progress, in particular, is an admittedly vague term and could accommodate any number of interpretations. Nisbet (2009) defined social progress as "improving quality of life, or solution to problems. Alternative interpretation as harmony with nature instead of mastery, sustainability." The latter harmony with nature was used for some of the results related to environmental projects, but that still leaves the bulk of the articles unclassified using the existing list of frames.

Newspaper genres structurally mediate the use of communication frames. In this case genre is being used as a term to describe the different types of articles that journalists write and newspapers publish. The genre of the articles was coded during the analysis phase of the dissertation and is discussed in more detail in the next section.

Genre may have affected the coding for frames found or not found in this study. Some of the articles collected for study were very brief, less than 150 words. In most cases these brief articles were announcements about coming events related to citizen science, for example a lecture being delivered at a local school about the topic. In these cases citizen science is used just as a label and rarely even described or engaged with as a topic. The brevity of these articles afforded very little space to frame citizen

science in a positive or negative way. More details about the analysis of genre is in the next section.

5.1.2 Genres

A genre is defined by the Oxford English Dictionary as a "kind; sort; style or A particular style or category of works of art; esp. a type of literary work characterized by a particular form, style, or purpose." ("Oxford English Dictionary," n.d.) A textbook on discourse analysis says that "Genres are the specifically discoursal aspect of ways of acting and interacting in the course of social events ... So when we analyze a text or interaction we are asking how it figures within and contributes to social action and interaction in social events." Fairclough (2003, p. 65) In summary genres are ways of categorizing discourse based on form, style, or purpose. These categories can then be used for particular social purposes, for example the scientific research article is used to communicate results among a set of experts. A newspaper article or a press release has a different structure and purpose, communicating results to a non-expect audience. Looking back to the discussion of expertise in chapter 2 a scientific article is used for an esoteric audience of specialists; the newspaper article is used to disclose the results of esoteric science and to integrate that scientific knowledge with the public concerns of the audience.

Mass media is a type of specialized discourse which has its own generic forms. In the area of newspapers and print media there are common forms such as: news reports, review articles, features, editorials, letters to the editor, etc. (Bhatia). Each

of these forms accomplishes a specific purpose. Reports and review articles usually provide information to the audience, whereas editorials outline opinions on relevant topics. Letters to the editor provide a method for two-way communication between audience and publisher.

Genres organize the labor within newsrooms. Different reporters are assigned to 'beats' or subject areas in which they develop a network of sources and expectations. Some reporters work on daily news, while others focus on in-depth reporting for features or investigative journalism. One of the current challenges in contemporary newsrooms is the general decrease in the number of reporters dedicated to science. The economic structure and organization of newspapers is undergoing significant shifts in the wake of technological developments such as the internet. Major sources of advertising support for newspapers have shifted to other media. The result is that newspapers are often short-staffed and work is distributed among a large number of generalists instead of specialists. Other reporters, who may not have any experience with science topics, may be forced to report on stories for which they have limited familiarity and limited networks.

For this study all of the newspaper articles were classified into four genre categories: announcement, editorial-opinion, profile, and report. An announcement is a preview of a future occurrence such as a lecture to be delivered at a local university or a citizen science project that yet to begin. Editorial-opinion are comments on a particular issue, usually citizen science or a specific example of citizen science working on a relevant news issues such as the environment. A profile is centered around an

Table 5.2: Genre Classification of Newspaper Articles

Type of Genre	Count of Articles	Percentage of Articles
Announcement	63	38
Opinion-Editorial	12	7.2
Profile	9	5.4
Report	83	50

individual person and their experiences, usually presented because of some type of honor they have received or are about to receive. Finally a report is a typical news article that reports on particular events such as the use of a citizen science project at a local park. These genres follow some of the standard categories such as news reports and editorial. The biggest divergence is with the announcement and report categories which emerged because of the different temporal orientations of the stories in the sample. A large number of stories were about events that had not happened yet, many of these articles were extremely short, sometimes less than 150 words, and seemed to form a structural category of their own. Other analysts might merge the report and announcement categories into a single news report category.

The results of the genre classification are in table 5.2

5.1.3 Labeling

The generic and structural features of the articles being analyzed may be one of the reasons that so few science communication frames were found. Announcements, in particular, are one genre that leaves very little room for framing about science in general or citizen science in particular. With only 150 words there is very little room

to discuss any of the issues that may relate to citizen science, instead it is more likely that 'citizen science' will be used as a label of convenience to describe a particular project, event, or person.

> I feel that press see it as a key word; its a word that they want to include in their writing, because it catches peoples attention, just like bees and just like plastic and biodiversity. And really, if for me as a researcher conveying my work, I want as many as people as possible to hear about it and to read about it and to critique it. Its important for me to use those key words so I can get the message out. (R2)

Another genre that used citizen science as a label were the profiles. Here the usage was almost always future oriented indicating an intent by the person being profiled to begin a citizen science project sometime in the future to continue their current work.

Activities that were previously just considered types of volunteering are now being relabeled as forms of citizen science.

> It was part of the story, I guess. Its just one of those terms that is tossed around in certain circles. (W1)

> [I] think Audubon is kind of using that as kind of a marketing type thing, because it seems like these days everythings got to have a catch phrase or some kind of handle to hang on it. (W1)

Using citizen science simply as a label has potentially damaging effects on the perception of citizen science as a whole. On the one hand a label can function as a

normalization device making the labeled topic seem ordinary or similar to previous experiences. Labeling can also be dismissive, treating the object as though it were being summarized in a single phrase. In fact this is one of the functions for frames in communication - the simplification of previous facts which took complex verbal or written explication into shortcuts which are accepted by an audience without question. The problem is that labels can also become vehicles for the transmission of both negative and positive frames. When definitions are no longer connected to the written use of a term the meaning of the term may become buried in the background and subject to slippages.

5.1.4 Types of Science

The newspaper articles and press releases were also classified for the type of science that the main project was engaged in. In some cases the articles were summaries of multiple citizen science projects and therefore were not coded to a specific science. Five major sciences categories were used: astronomy, environment/ecology, historical, medicine, and ornithology. Environment/ecology encompassed any story that focused on a particular biological species or particular environmental niche, for example a project on koala monitoring or an engagement program for blind children at a local park. Historical projects focused on looking back at particular records or archaeological evidence. Astronomy, medicine, and ornithology were used in their typical connotations. The results for the documents studied in this dissertation are shown in table 5.3.

Table 5.3: Type of Science in Newspaper Articles

Type of Science	Count	Percentage
Astronomy	10	7.0
Environment and Ecology	76	58
Historical	6	4.0
Medicine	5	3.0
Ornithology	34	25

Ornithology was well-represented in the present sample of articles because of multiple stories about the Audubon Christmas Bird Count which took place in the latter half of 2013. Even so there were a number of ornithology articles that appeared to be part of regular columns about nature or the environment, which suggests that ornithology is a topic that gets a significant amount of coverage throughout the year by virtue of overlapping with audience interests and topics related to nature such as gardening. When combined with the number of environmental/ecology documents the biological/earth sciences represent the large majority of newspaper stories about citizen science during this time period. This makes sense historically because these sciences have been open to amateur participation in the past (Bonney, 1996).

Press releases were also coded for dominant science. The number of press releases was much smaller than the number of newspaper articles so trend detection is much more difficult. One interesting result to note is the larger proportion of press releases that discussed astronomy. Astronomy was uncommon among newspaper articles but much more common among press releases.

One potential explanation for the greater proportion of astronomy press releases may be the limits of the local journalism cycle. Newspaper articles, as the earlier

Table 5.4: Types of Science in Press Releases

Type of Science	Count	Percentage
Astronomy	2	18
Environment and Ecology	6	54
Historical	1	9
Medicine	2	18
Ornithology	0	0

genre analysis showed, have certain expected structures that need to be fulfilled. One of those common structures is a local connection and quote. Reporters often look for a local news hook or personality to provide a quote which makes the story relevant to the local audience. Birding appears to be much more popular at the local level. Even in a newsroom with limited resources there may still be a reporter who works on local environmental issues (W-1). Regular columns on birding and local ecological news are also present in the sample of newspaper articles. Astronomy had no such regular local press in the sample of newspaper articles examined for this study. So there appears to be some evidence that astronomy is being promoted by public information officers and scientists but is struggling to generate wide media exposure based on this promotion. Further studies which widen the scope of the content analysis completed in this project may be able to demonstrate differential effects based on the type of science being discussed or promoted.

5.1.5 Creating Frames

Detecting the creation of communication frames is difficult because the process depends on habitualization as assumptions about a topic are developed over time and

become embedded in linguistic formations. It is often easier to see frames in conflict and then identify an occasion where a new frame is created to offset an alternative frame. Such a case was present in the presentation of one citizen science project and its interaction with the Today show on national television.

> I guess the media is kind of annoying. The media is very happy to twist anything into germs are disgusting because that's the sort of standard narrative. So I guess it has been sort of frustrating to try – because the media is a really powerful way to communicate your message to people but it's dangerous because they often have sort of a pre-existing narrative that they want to tell. For microbiology that's usually like, ew, there's germs on your cell phone. (R3)

One of the great challenges and persistent complaints of scientists when dealing with the mass media is the inability to deliver a complex message. Scientists can sometimes deliver a message that may alter or complicate a default frame used by reporters. However there are costs to altering the message and one of them may be a feeling of unease.

> Like with the Today Show we did two episodes with them. The first one with them was sort of painful. Germs are disgusting. The second one I ended up writing the teleprompter text and I just bashed over and over again the message that most microbes are good. Most microbes are good.

> I felt like a robot but that had an effect. So I guess I've learned to keep it simple and stick to the message, I guess, if that makes sense. (R3)

This quote captures the frustrations of scientists who are trying to communicate via the mass media. It also captures the frustration that messages are being simplified in order to adapt to the needs of the media instead of the needs of the scinece being presented.

Framing a message for the public directly may be a very different experience.

> So I guess that would be my biggest challenge in doing something citizen science, I would say, is actually the media. Because when we talk to people it's very easy to get them excited and interested and engaged and to communicate what we want. But when we talked to the Today Show and they communicate to people, the message can be easily twisted. (R3)

There are many was to intervene in the framing of a subject beyond direct interventions such as rewriting the copy presented on a teleprompter. One way to create a frame is through repetition of common conceptual connections. Juxtaposing two idea repeatedly may increase the audience's association of those ideas.

One common frame, especially among researchers and project staff, for citizen science was education. Many of the subjects interviewed talked about the potential for citizen science to help people learn about the world around them and the scientific method.

> Because I value so highly the idea of educating people – I like the fact that this provides a way for us to engage people. In general, particularly in microbiology, most people have – oh my god. Germs are disgusting and that's about the extent of their day to day thinking about microbiology. So there's a huge scope for education and I think citizen science is a great way to do that because everybody wins. The public becomes better educated about microbiology and there's cool science you can do with this kind of data. So to me it's sort of a no brainer to be doing citizen science. (R3)

> So educators are a really big demographic that we try to target whenever we promote our content. Students are another one because that kind of goes hand in hand with educators. We want teachers to be able to promote these projects with their students and for their students to be able to participate and get more hands on experience with science whether inside or outside of the classroom. (W2)

There was some evidence that the education frame migrated successfully into media stories. Direct quotes by project managers or researchers sometimes focused on educational outcomes. So did stories about citizen science happening in educational settings, either at schools or in other settings such as parks and museums.

5.2 Themes

5.2.1 Science

There are two concepts to be discussed within the theme of science. First is a general definition of what science is. Science can be seen as a method or as a social activity as described in chapter 2. The definition of science is mentioned a number of times in both interviews and newspaper articles.

One thematic description of science links it back to the discussion of Deweyan inquiry from chapter 3. Inquiry is a process of defining the conditions of a situation and then finding potential solutions to the problem which can be tested by experience. Science similarly can be seen as a process for systematic inquiry into nature.

> "Science is a process, but often we focus in on the products, the final results of everything," says McClain. Coverage of courts or government emphasizes the march towards the final verdict or law as much as the eventual outcome. Yet reporters and researchers tend to snap to attention at the last stage of the scientific process, the published paper.
>
> "It feels like we've fallen into a communication model where we've stopped getting people excited about the process." (LN-6)

Viewing science as a process has many affinities with citizen science. The idea of inquiry described by Dewey is process-focused as questions are developed in response to confusions in the environment, answers are proposed, and then evaluated

based on their results. Citizen science combines the process of inquiry described by Dewey with the social world of expert judgment represented by professional scientists. Furthermore, combining the ideas of researchers and citizens leads to mutual benefits for both sides of the exchange.

> Citizen science is the name given to an approach to research which has benefits for both researcher and citizen. One of the values is to provide an understanding of the basic paradigms of scientific method to large numbers of people. In a nutshell, this involves doing what all scientists do: collecting data in a disciplined way in accordance with a well-thought through protocol. (LN-136)

Mutual benefit was a common explanation for the power and popularity of citizen science.

> I often say that it's a way for people to be involved, directly, with scientific research and concurrently, it's a way for scientists to being able to obtain more information, more data, in a way that they are kind of crowd sourcing it so that they can expand their reach. So those are the highlights or what I usually say when I describe citizen science. That it's just kind of a two-way. It benefits both groups, the citizens and the scientists. (S1)

Numerous types of activity are being encompassed within the category of citizen science. Some of the connections found included the following:

- Crowdfunding (LN-106, LN-325)
- Involving untrained members of the public (LN-120)
- Part of a trend toward openness - e.g. open access publishing (LN-6)
- Volunteer activity (LN-25)
- Connecting with science work (LN-175)
- Bringing together a network of non-scientific volunteers (LN-136)
- Uniquely human, power of many (LN-207)
- Filling environmental gaps (LN-224) and lack of resources (LN-319)
- Ease of participation (LN-357)

The diversity of these descriptions for citizen science in the mass media suggest that the definition has not solidified into common wisdom or cliche. Part of this confusion is caused by the many different descriptions which are given by researchers pursuing citizen science projects. But another part of the confusion is the struggle to understand collective knowledge projects in the age of the internet. Studying the framing of citizen science is one way to resolve some of these tensions regarding the definition of the activity.

5.2.2 Citizenship

Citizenship was used in a number of places to indicate a connection between citizen science and community action or policy. The results of citizen science can be used beyond just scholarly research.

> So I think what Citizen Science does is it advances sciences, which in turn directly informs community decisions. So in areas as wide and diverse as disaster response, community planning, land use planning, biodiversity, conservation, I think that Citizen Science directly contributes to our ability to make wise science-based decisions in those arenas. (R1)

Being a citizen science may even be part of a role which adds more than just being a volunteer. There is a palpable sense of involvement in a collective enterprise that extends beyond the boundaries of the research university into the community as a whole.

> It creates the sense that they're apart of the research, they're not just a site or a helper or a volunteer, they're a citizen scientist, they're helping with the science. And I think it gives them a bit more ownership over the work. (R2)

> When citizens are involved in knowledge making, they feel part of a collective enterprise and adventure, not distanced from the ivory towers where there is only space for a few well-qualified people to work full-time on research. (LN-319)

One of the aspects of citizenship discussed in chapter 2 is the balance between rights and obligations. The discussion of citizenship within the social world of citizen science is still quite limited. There is some emphasis on participation as the quotations above indicated, but obligation and rights to contribute are still absent.

5.2.3 Expert-Novice

Articles and interview subjects mentioned expertise only to downplay it almost immediately. The implication being that anyone could be involved in citizen science without much training or experience.

- Don't need a background in science (LN-237)
- Don't have to be an expert to take part (LN-21)
- No special knowledge (LN-34)

In addition to the discounting of specialized knowledge there were occasions where the ephemerality of the experience was mentioned. Being a citizen science was presented as a short-term role that could be taken on for the length of time it takes to visit a park or museum.

- Wear the hat of a data collector for a day (LN-317)
- Be a scientist for a day (LN-317)
- Gap filling (LN-319)

Some researchers deliberately designed their projects to place minimal burdens on the participants in order to increase the enjoyment of the activity. Volunteers were not getting paid so other forms of reward were needed. Sometimes the tasks were difficult even for the scientists to accomplish, so expecting volunteers to do them would be impossible.

> For me, the key has been to not expect the citizen scientists to feel they need to identify bees. This is a common thing in bee research involving citizen scientists lately is expecting people to take pictures of bees on flowers, or to identify bees by some kind of a feature, you know, their size or their shape or their color, but its really difficult to do, even with a microscope and a dead bee on a pen its hard to identify sometimes.
>
> So I didn't want to put the onus on the citizen scientists to do anything too excessive, I wanted it to be more fun for them. So I think going forward, and how citizen science research has impacted my own work and the direction of my work, it would be more focusing in on how to use them most effectively and then leaving other things for me to deal with. (R2)

Minimizing the need for expertise may be one way to attract wider audiences to participate in citizen science projects. Especially if volunteers will only be visiting a museum or park for a single day. However there are also citizen scientists who want to learn about a particular topic. For those engaged in serious leisure deemphasizing knowledge production or the attainment of expertise may be a disincentive to

participate. Projects must carefully balance between ease of engagement and learning outcomes.

5.2.4 Professional-Amateur

For many people engaged for an extended period of time with a citizen science topic leads to significant gains in experiential knowledge. Ornithology or astronomy become a matter of serious leisure which can constitute a significant part of a persons identity.

> I guess if I would draw a parallel, it would be just to tell them, you know, while they may not have a formal education in whether its avian biology, fisheries biology, mammalogy, anything like that, it would be like accustomed to somebody who maybe has a hobby of woodworking, cabinet building thats always been an interest of them. So they have been doing woodworking for 25 years and have become sort of an authority just through their experience and their interest in the thing. (W1)

The reaction from journalists can sometimes be incredulous.

> Amateur is the key word. There were no rewards for the 40,000 hardy souls who took part come rain or shine. Standing in the freezing cold to count geese or waking early to listen for woodcock performing their 'roding' displays required the highest levels of enthusiasm and devotion. The four-year study period achieved almost blanket coverage of Britain and Ireland. (LN-76)

Even if there is a long historical legacy of amateur science.

> Citizen science is crowdsourcing meets Isaac Newton or Benjamin Franklin, to name a couple of long-ago famous amateur scientists. (LN-277)

5.3 Citizen Science and the Public

5.3.1 Scale and Scope of Citizen Science

Citizen science has grown rapidly over the past twenty years since it was first introduced by Irwin and Bonney in the 1990s. The following section describes some of the trends showing the growth in citizen science using data gathered from bibliographic sources, and the internet.

The bibliographic and web trends are relevant to the relationship of science and the public for a number of reasons. First, increasing interest in citizen science among researchers, represented by the bibliographic data from Scopus and Web of Knowledge, shows growing awareness about the value of volunteer participation in order to meet the goals of scientific research (see figure 5.1). The significant focus on validation and data quality discussed in chapter 1 show that researchers are already addressing one of the major barriers to expanding the reach of citizen science.

Second, the web trends data collected by Google show that citizen science is becoming an increasingly popular term over the past decade see figure 5.2 This data overlaps with some of the earlier results about the use of citizen science as a label by

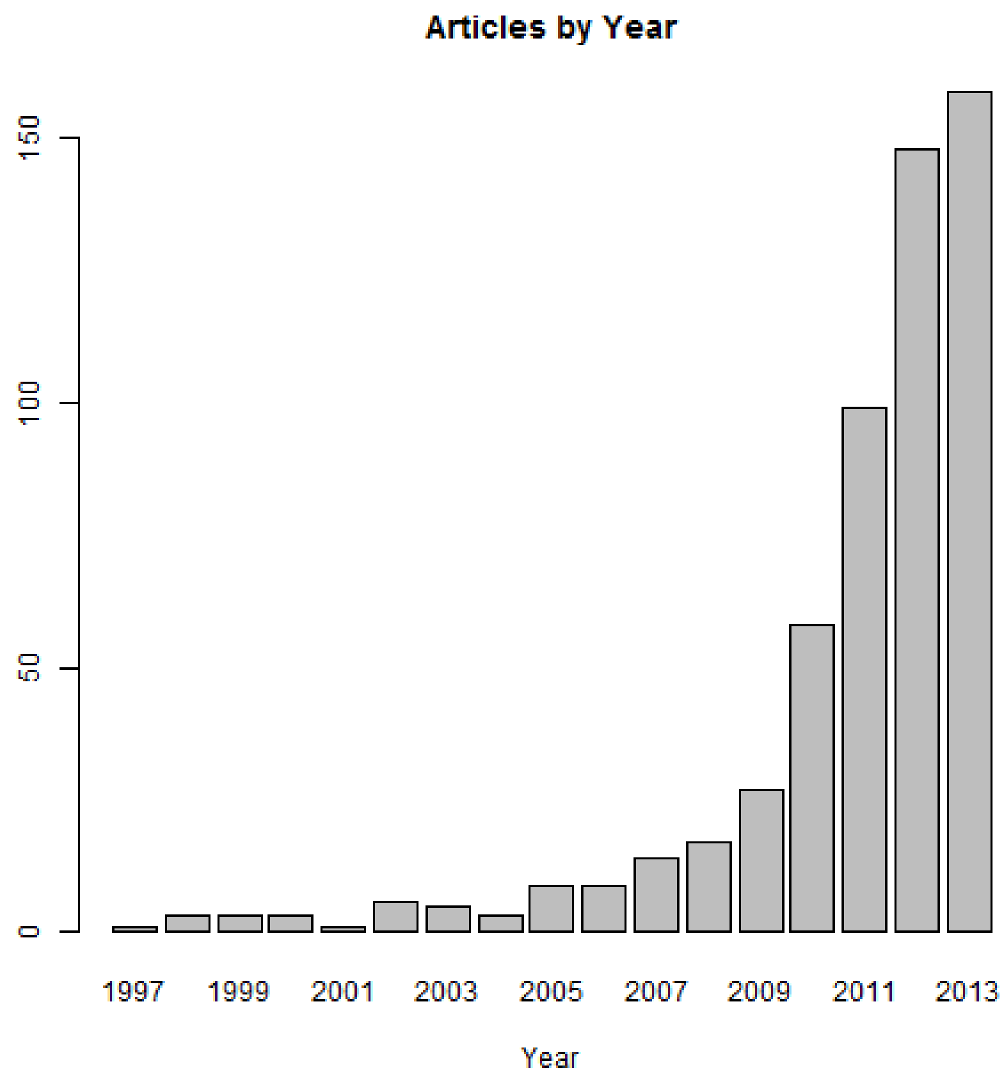

Figure 5.1: Academic Journal Articles on Citizen Science per Year

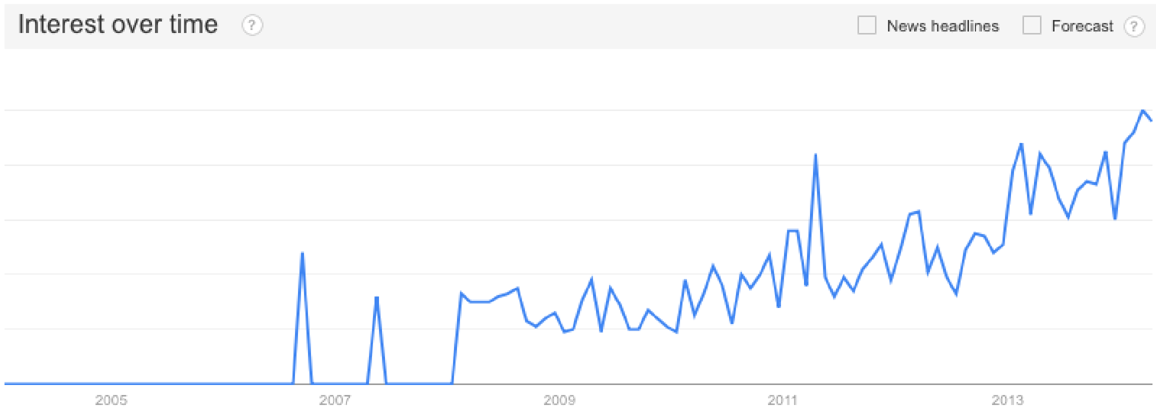

Figure 5.2: Google Trends for 'citizen science'

a variety of groups that have been involved in science before. The label is becoming more common and potentially more valuable over time.

Another trend could be detected in the number of newspaper articles which contained the phrase 'citizen science'. The number of articles found for 2013 was much larger than previous years.

5.3.2 Boundary Management

Citizen science encounters a number of important boundaries. There is the boundary between the public and technoscience which has been contested since the initial professionalization of science. Some scientists view citizen science as a threat to their legitimacy and social power. But other parts of the culture celebrate do-it-yourself activity and include citizen science within that umbrella.

> There's whole papers written on the subject of "democratizing science", and that's a power struggle shift, it's a paradigm shift that's really

> having large consequences on how people view Citizen Science. In one way scientists view it as a threat, and it's somewhat undermining their expertise, and they're a little concerned about members of the public with varying degrees of training participating in that endeavor. The other end of the extreme you see complete embracing of the paradigm shift with through DIY culture, Do It Yourself culture and other such sub-cultures if you will whereby communities are really feeling empowered to take stewardship into their own hands, and/or take whatever issue they're looking at, and at least get a better understanding of what's going on in the world around them. So I think there's a bit of a struggle in different camps that are trying to figure out the pros and cons of this approach. (R1)

Within citizen science itself there is another boundary over the degree of participation of volunteers. On one side are those who view volunteers as instrumental resources to be deployed under the guidance of researchers in order to solve particular problems. On the other side are the proponents of opening science up to participation by volunteers, leading to a co-created model of knowledge production.

> Well, it depends on what you're goals are. There's two kinds of citizen science. Because I've organized these two workshops on citizen science it's something I've thought about a lot. There's the Mechanical Turk version of citizen science, which is where you want to use – a scientist wants to

> use members of the public to do something that they otherwise couldn't do. That's not what we consider to be citizen science. For us it has to be a two-way interaction. The citizens in question have to be engaged and interested and want to participate and learn something from it. So we're not looking for automated sample collectors, we're looking to teach and educate people. If you look at different citizen science projects, there's definitely some that are of each of those two categories, which I'm sure you're encountered in your work as well. (R3)

The growth in citizen science, both for academic and general audiences show success at involving the public into science. Changes in the boundaries between science and the public, as well as within citizen science, also show changes in the relationship between science and the public.

5.3.3 Roles and Relationships

Four different roles were identified during the proposal stage for the dissertation. Each role was involved in developing the communication message and framing for citizen science projects. A diagram of the roles can be found in figure 5.3. Scientists or researchers are at the heart of this initial role diagram because they provide the impetus to begin the project and then distribute information to other people including project communicators, public relations staff, and journalists. In addition to the people mentioned above the diagram contains additional boxes representing

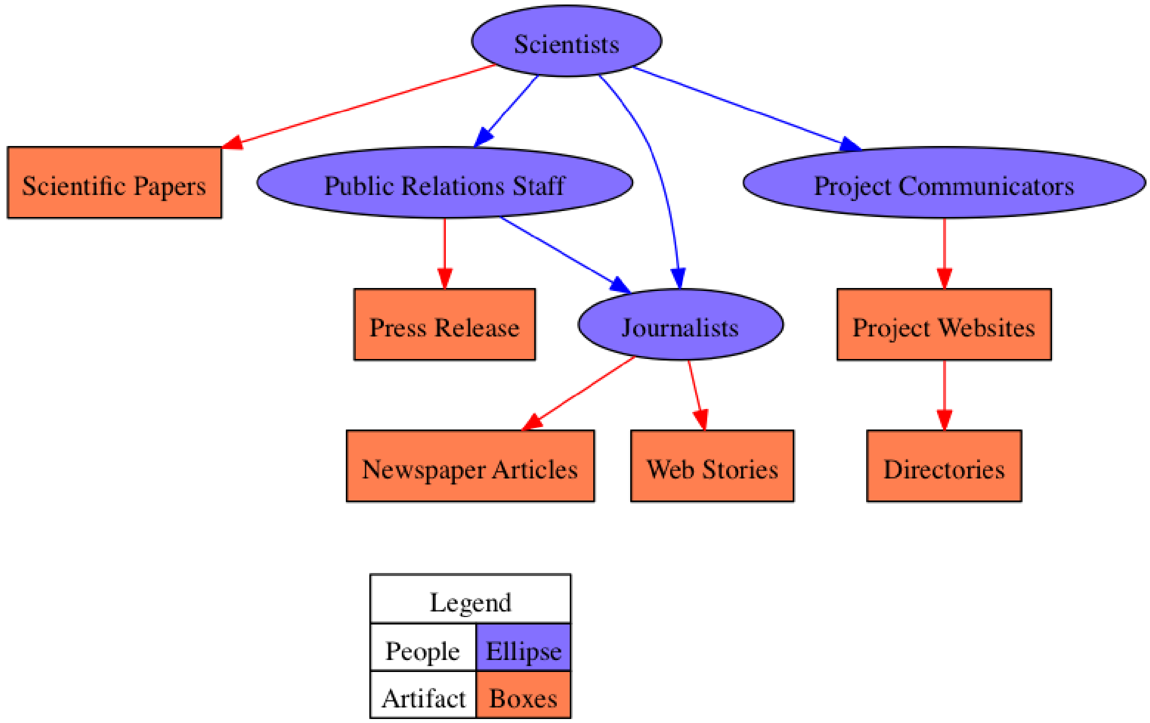

Figure 5.3: Initial Diagram of Communication Process

the printed and web-based artifacts which are created by the people in each of the roles described. These artifacts formed the core collection of documents analyzed in this dissertation and included scientific papers, press releases, newspaper articles, web stories, project websites, and directories of citizen science projects.

One drawback of this initial communication diagram was its focus on the key role of scientists as the instigators of communication within a citizen science project. Other roles play as important a part in the communication process as the scientist. For example project staff may attend different professional conferences than the scientists and become the de facto representative of the whole project to a community. They may also be deeply engaged in developing communication materials which are designed for groups not included in the initial diagram such as educators.

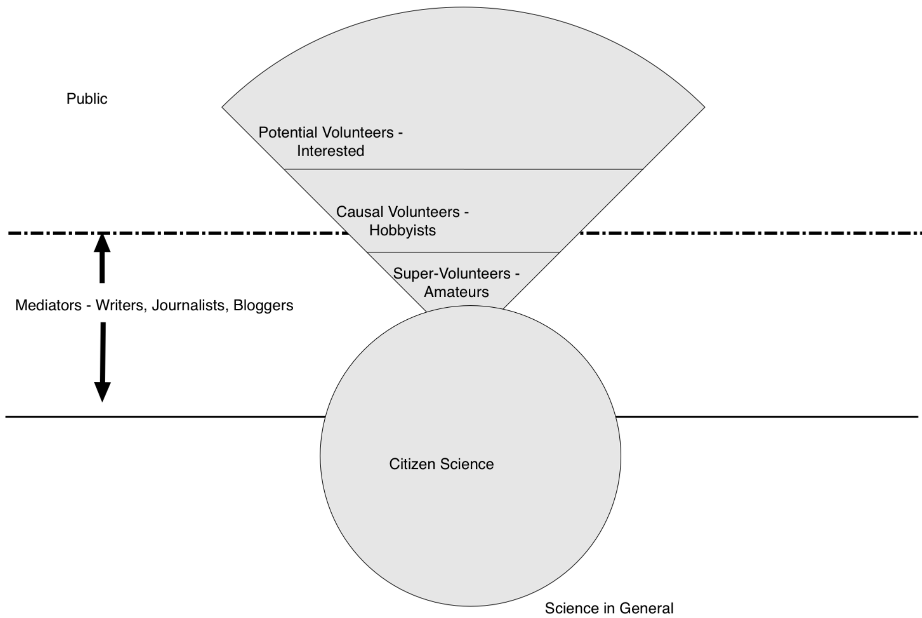

Figure 5.4: Social Arenas Map of Citizen Science

As data was gathered and analyzed another attempt was made to diagram the communication roles within citizen science projects and between the projects and the public. A new social world/arena map was produced using situational analysis and is shown in figure 5.4. A key difference in the new diagram was the elimination of directional areas of communication flow between different groups. In this diagram the figural position represents the position of each group within the overall world of citizen science.

Science in general is represented by the space at the bottom of the diagram and the public at the top. Citizen science sits between them in a circle that

overlaps both science and public arenas representing the hybrid nature of how citizen science projects combine both arenas. A vertical cone rises from the top of the citizen science circle and represents the volunteers involved in the project. The volunteers are conceptually divided into super-volunteers, casual volunteers, and potential volunteers. The division follows the theoretical thinking of social worlds which contain a gradation of participation levels from insider, to regular, to tourist, to outsider. The amount of time donated by a volunteer decreases as the cone expands with the uber-volunteers closer to the center of the project.

The divisions between volunteers can also be theorized using the serious leisure perspective presented by Stebbins. In this viewpoint amateurs are intensely engaged in an activity such as citizen science and may even achieve levels of expertise comparable to some professionals. Next are the hobbyists who parallel the casual volunteers who may occasionally dabble with a project but do not con sider the activity to be a core part of their being. Finally there is the public who may or may not be interested in the activity or aware of its existence. Citizen science is therefore an example of a public-amateur-professional complex.

The final group which needs to be placed on the arena map are the mediators who provide an interface between science, citizen science, and the public. Mediators may or may not be active participants in the project. In some cases a mediator may be a project staff member who is quite deeply involved in the activity of the project. Other mediators are less likely to be involved with a particular project and may perform a news aggregation function. Scistarter.org is an example of one such

aggregator which collects information about many various projects and highlights them in a regular web log. Still other mediators may be professional journalists or public relations personnel who are tasked with reporting on a citizen science story but have no ongoing relationship with the citizen science community or activities. All of these roles can be positioned within the two lines which separate science and the public.

The boundaries between these different worlds are mediated in a number of ways. Media is a primary mediator in the form of blog posts, newspaper articles, and press releases. Boundary objects may be created at various points to facilitate the translation of a citizen science project into other genres. So a newspaper article, for example, may use interviews with project participants as a way to enhance local interest or connection to a particular project making the abstract more concrete. A set of education materials may be incorporated into a curriculum in order to carry the message of citizen science into the classroom. All of these negotiations are ongoing and subject to different types of framing. An overall frame emphasizing education may be an agreed purpose for many of the people involved. Situational analysis can also be used to examine the positions taken by various groups and people within a social world. Figure 5.5 shows the positions of the people interviewed for this project along two dimensions. The vertical dimension again traces the spectrum between science and the public. The horizontal spectrum shows variations in the depth of involvement following the social world model from insider to outsider.

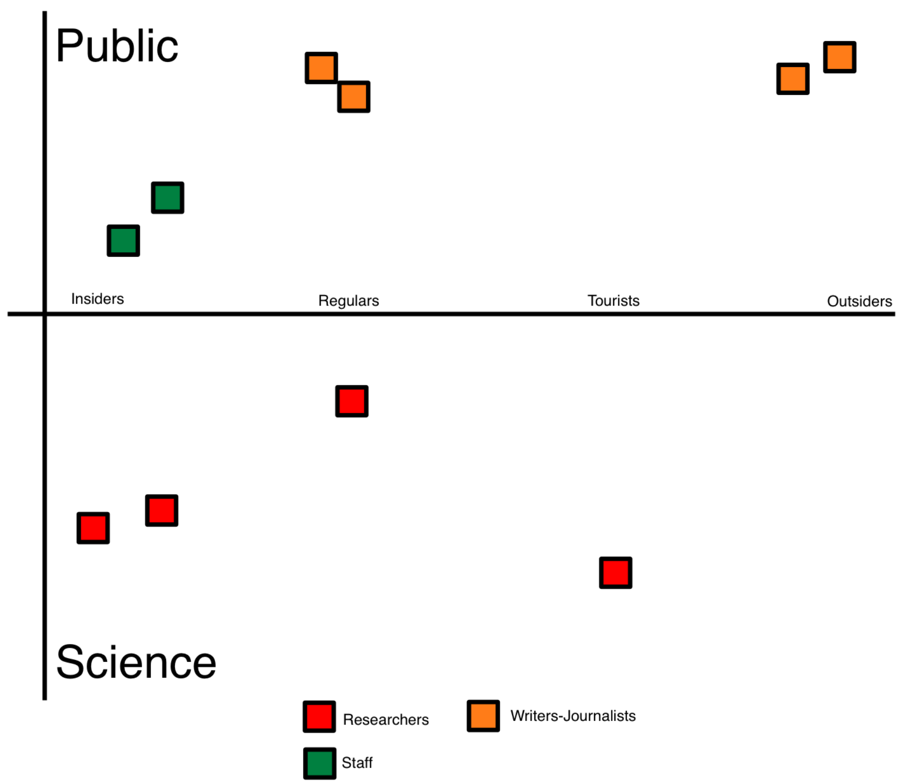

Figure 5.5: Positional Map for Citizen Science

The four researchers interviewed are shown below the horizontal line but spread out a bit. Two of the researchers are actively involved in building the infrastructure and community of practice around citizen science and are therefore labeled as insiders. The other two researchers are distributed between regulars and tourists based on their ongoing or one-off participation in citizen science. Insiders who are closer to the public are project staff. Regulars who are interacting with the public are promoters of citizen science usually writers for web logs or other media which pay a significant amount of attention to citizen science. The final group are journalists who are outsiders and close to the public. It should be noted that none of these positions are permanent and that people may move back and forth based on personal experiences. But the roles of scientist, staff, and journalist are still present as suggested during the proposal stage.

The positional map can aid the analysis of citizen science by looking for gaps which may not have been filled during the current research project. For example scientists who are outsiders to citizen science were not interviewed for this project and may have a different perspective on the communication frames being used to promote and explain citizen science to the public. The map also raises the question of which boundary - between public and science or insiders and outsiders - is more difficult to cross. Both directions may require adjustments to the communication frames in use.

Chapter 6

Discussion

6.1 The Tension at the Center of Citizen Science

One of the key arguments of this dissertation is for the existence of two different views of citizen science. On the one hand there is an emancipatory-participative view of citizen science which believes that citizen science can significantly alter the relationship between public and science by making changes in relations between experts and non-experts. The second view is the instrumental-pragmatic which believes that citizen science is another tool or instrument in the arsenal of scientists and will have an impact by extending the capabilities of current science without significantly altering the social relations between the public and science.

The literature review of citizen science presented in chapter 1 showed the nearly contemporaneous uses of the term by both Bonney (1996), Irwin (1995). The origins of Irwin's definition are in science and technology studies. At that time, in the early

1990s, STS was incorporating the work of Brian Wynne and others which showed that local expertise sometimes trumped the laboratory experience of government scientists (Wynne, 1993). At the same time the second wave of science studies, starting in the 1970s, with laboratory ethnographies by Bruno Latour and others were calling into question the claims of scientists that they were behaving objectively, unswayed by any external factors (Latour & Woolgar, 1979; Sismondo, 2003). Research in risk perception was also calling into question the idea that supplying the public with more information would automatically lead them to accept the correct, scientific perception of appropriate risk from technology. These three developments form the immediate intellectual situation in which Irwin wrote his book defining the idea of 'citizen science.' It was a vision that responded to the perceived failure of technocracy to recognize both the knowledge-experience and the rights of local citizens to participate in techno-scientific decisions. This is the emancipatory-participative view of citizen science.

The instrumental-pragmatic view of citizen science can be found in the work by the Cornell Lab of Ornithology and (Bonney, 1996). There is a long tradition of amateur activity in the sciences which was described in chapter 1. Ornithology and astronomy are two sciences that have been open to amateur participation for many years. So it is no surprise that the Cornell Lab of Ornithology developed a number of programs to aggregate volunteer data, starting with the FeederWatch program in the 1980s . When Bonney used the term 'citizen science' he was calling upon a significant history of public participation in science, specifically in ornithology. The orientation

of the instrumental-pragmatic approach to citizen science is toward the collection of data from across large scales, geographic and temporal, which could not be easily managed by individual scientists or even typical group research projects. Data, both gathering and analysis, is the central strategic goal for this type of citizen science.

The instrumental-pragmatic use of citizen science focuses on extending the capabilities of current scientists into areas where they may not be able to effectively or efficiently deploy observers or themselves. The goal is to extend the sensory net of existing scientific projects through the deployment of new technologies and social organizations. The emancipatory-participative use of the term focuses on the potential of bringing non-scientist into discussions about the future and current development of science and technology. The goal is to improve the relationship between democracy, science, and technology by bringing more voices, especially non-experts, into the dialog about science and technology policy.

The division between these two views of citizen science can still be seen in current arguments about the future direction of citizen science including the three following examples.

Public, citizens, crowds, or volunteers. The choice of name for any phenomenon can have an impact on the perception of that phenomenon. This is one of the lessons of framing research. So it should come as no surprise that different names used to describe participation in science by non-professional scientists may have an effect on the future directions of funding, research, and recruitment.

Four different words have been used to emphasize different aspects of citizen science. Crowds are undifferentiated and interchangeable. Mutual understanding with a crowd is unlikely. Public connotes openness of both results and recruitment. Anyone can and probably already is a member of the public. Volunteers donate their time without compensation, perhaps without any expectation of reward or benefit. Citizen shifts the connotation even more because citizen are able to intervene in public affairs as a matter of right, not just preference. But citizens also have obligations which can be called upon to encourage their participation, for example obligatory medical data sharing or testing which could be construed as a form of 'citizen' science. All of the terms associated with the activity emphasize slightly different versions of the relationship between scientists and participant. Some relationships are more active, others more passive. Choosing one of the terms affects future discussions of the topic and also reflects a position on the spectrum between emancipation and instrumentation, pragmatism and participation.

Two other terms that arise in discussions about citizen science are sensor and instrument. The metaphor of citizen scinece volunteers as a collection of sensors is very powerful. Treating citizen science as a novel instrument helps to frame citizen science in a way that professional scientists are familiar with because the tuning process of a sensor or instrument is a common task in normal science. In fact a sensor is one of the forms which help to determine the major research paradigms for scientific investigation (Kuhn, 2012). The drawback of describing citizen science as a new instrument or new sensor is a potential to minimize the participative activities of

volunteers. Sensors and instrumens lean toward an instrumental-pragmatic framing for citizen science instead of the emancipatory-participative.

Accuracy and validity of data. The debate over the accuracy of volunteer observations is another symptom of the division. No one involved in citizen science would argue that data should not be correct. We are still trying to do science and accurate data is crucial for success. However questioning the validity of citizen science data can also function as a form of boundary maintenance. Defining what types of data can be considered for study is an important management technique for a professional group like scientists. Questions about validity may be a passive-aggressive form of opposition to citizen science.

Education as the primary goal. The emphasis upon education by most of the researchers involved in communicating citizen science is another example of how boundaries may be drawn up within the social world of citizen science. Within the community of citizen science there are strong constituencies for both education and scientific research. One of the interview subjects described a workshop that he helped to organize where the different goals between scientists and educators created some frictions. But having education as primary focus can also limit the imagination of scientists and research managers about the ability of volunteers and how much of a role they can play in the design of a citizen science project.

6.2 Crossing the Boundaries Between Science and Media

One important challenge to the success of a citizen science project is recruitment. Enough volunteers need to be persuaded to donate their time and effort to helping the project meet its goals. The main route for reaching potential participants is frequently through the media. Other routes such as social networks and amateur groups also help to put out the message about citizen science projects to potential volunteers. Media is important because it reaches a large audience, including people who may not already be part of a social world involved with or connected to existing citizen science information channels such as bird watchers. So one main purpose for a citizen science project to engage the media is to recruit more participants. More participants usually means more data and quicker potential results.

Getting the attention of the media can be a challenge because there are structural and generic challenges to spreading the story about citizen science. The structural challenges facing print journalism of all kinds are particularly striking. The traditional economic model of selling advertising and subscriptions to support reporting of the news is being challenged by the internet. Free content is abundant on the internet making it easier for readers to forego subscriptions. Advertising is also changing with sites like Craigslist replacing many classified ads and business targeting their advertising through online companies such as Google. These economic challenges have an immediate effect on science reporting by reducing the number of dedicated

journalists who work on science and technology issues. The technical nature of science and technology requires extensive experience in order to understand the topics and then report on them to a general audience. A reduction in the number of science journalists may lead to a reduction in quality of the science news that is delivered to the public (Bauer, 2014). For citizen science this means that gaining the attention of journalists may be increasingly difficult and the journalists who are interested in the topic may lack contextual knowledge about the successes and failures of citizen science.

The generic challenge for citizen science programs is when and how to get news reports about citizen science in the media. A large number of articles in this study were either announcements or reports. Announcements were forward looking, either introducing new citizen science projects that were now looking for volunteers or suggesting that a citizen science project may be created at some time in the future. The use of citizen science in profiles was also frequently forward looking toward project which might be started in the future. The growing popularity of citizen science contributes to an increased frequency of citizen science being mentioned in connection with notional projects which are not even ready to begin accepting volunteers but are just proposals or ideas in the head of an individual researcher. Reports, by contrast, were backward looking and reported the results or some other outcome, such as a public event, of an existing citizen science project.

All three of the genres mentioned suggest that there are certain times during the course of a citizen science project when the chance of getting media coverage

is increased. The initial release of a citizen science project to the public is one significant media window when a project can be publicized to a wide audience. Another propitious time for publicity is when publishing results because a significant scientific report or publication may attract the attention of journalists. Profiles are much more difficult to control because they are often driven by the presentation of awards, retirements, or other events beyond the influence of a citizen science project. The key finding is that projects should capitalize on temporal media windows when news coverage is more likely. The press releases analyzed in this study show the same genre characteristics of announcements and reports about significant findings.

The exception to this temporal judgement and control occurs with the opinion-editorial pieces and columns. The former may be contributed by non-journalists such as researchers or writers who are interested in promoting citizen science. The latter are contributed by writers dedicated to a subject area such as environmental or outdoor reporting. In these cases the interest of the individual reporter may prompt the mention of or reporting about citizen science. There was no discernible temporal sequence which determined the publishing schedule of these genres of articles.

The low number of previous frame types detected in the current sample of newspaper articles may because citizen science is a less controversial topic than some topics which have been commonly studied in science communication. Controversy attracts attention from many groups. Journalists pay attention because controversy is part of news judgment and newsworthiness. Communication scholars pay attention to controversy because it generates significant corpora of articles to study and

psychological phenomenon to examine. For example, the different response of audiences to stories about global warming, nanotechnology, and genetically modified organisms are science communication studies driven by a focus on controversial topics. Scientists are particularly frustrated by the mass media focus on controversy because it is often perceived by them to be a distortion of the facts. Climate change is a perfect example of this perception. Most scientist working in the field believe that the scientific community has reached a consensus about the topic which they also believe should be reflected in the news reporting about the issue. A cynical conclusion from this would be that citizen science needs to become more controversial in order to get more attention - the idea that any public exposure is good. But this would be going too far. Dealing with a controversy can divert resources from more fruitful areas. Citizen science does not currently have enough resources to manage both promotion and controversy at the same time.

The factors which make a subject relevant enough to cover in the news do not have a simple explanation. Three major approaches to understanding news are the political-economic, social organizations, and cultural factors (Schudson, 2002). Each explanation highlights different features of the news system. A political-economic view of science coverage might emphasize the potential effects of advertiser funding. A sociological view could focus on the elite scientific and advocacy organizations which influence science reporting. A cultural perspective might focus on the social and psychological fascination people have for the novel and unusual. Numerous cross-cultural studies have shown that violent events get more proportionate attention in the

news than their actual incidence would predict (Schudson, 2002). News judgment is a complex topic and deserves more coverage than can be completed in this dissertation.

There is an underlying argument in much of the science communication research on framing that scientists need to adapt their own behavior in order to reach the public. Books like "Don't Be Such a Scientist" adopt this tone and talk about how scientist should match their material to other audiences (Nisbet & Mooney, 2007; Olson, 2009). As a basic psychological and philosophical argument this idea seems obvious. Audience affects messaging and information reception. But scientists are not the only party who is responsible for a failure to communicate science to the public. The mass media fails by focusing too much on controversy, having a limited definition of newsworthiness, and forcing complex issues into stultifying genres. The calls for communication reform should be directed at the media as much as they are directed at scientists.

Another generic commonality across both newspaper articles and press releases is the use of quotations. Scientific journal articles rarely use quotations to convey information but most journalistic forms do. The reasons for different styles can probably be traced to historical and social differences in the development of science and journalism as professions. Quotations are important for two reasons. One, they illustrate clear difference between the rhetorical expectations of science and journalism. Two, they pose another challenge for citizen science researchers working across wide geographical areas. Much of the journalism produced is dedicated to local communities and channels. A citizen science project with a national or global research

focus faces an additional burden of finding local sources for quotation in a news story. A local informant for a citizen science project is valuable not just as a potential source of quotations but also as a performative example of science happening at the local level. Finding these types of volunteers is one recommendation for improving citizen science communication and awareness in the media. It may be a role for which 'super-volunteers' can be recruited.

Finally there is a risk that citizen science may lose some of its credibility if it becomes too common as a term and is used as just another label for any activity that involves people engaged in protecting the environment. Environmental protection is an important goal and occasional benefit of citizen science but equating any environmental activity to citizen science threatens to eliminate a unique role for citizen science volunteers as more than just activists for a cause. Citizen science, at its ideal point, includes people in science for many reasons, reducing that to a political gesture may be a mistake.

6.3 Mediators at the Center

The research presented in this dissertation shows that mediators play an important role in distributing information about citizen science to the public. Mass media outlets such as newspapers and press releases are one element in the transmission chain. Other equally important outlets are weblogs dedicated to citizen science such as scistarter.org, PLOS citizen science blog, and Scientific American. These blogs

play a key role in promoting citizen science to an audience that is usually already interested in the subject.

Another key mediator for citizen science are museums, parks and science centers. Parks and museums may be critical sponsors for citizen science projects. Some even support particular roles in their organization which involve a focus on citizen science projects, for example a citizen science coordinator at a park. The roles encourage the integration of citizen science into the daily activities of the park or museum. Cultural institutions can inform the public about the existence of citizen science even if they do not directly engage in a particular project. Non-media channels for communicating the message about citizen science are incredibly valuable because getting the attention of the media is difficult. Finding mediators who can spread recruitment messages and scientific results during times when media attention may be absent is important to the success of many projects.

Educators are also a major mediator. Formal educators are often looking for additional curriculum resources which they can incorporate into science lessons. Some larger projects may have the resources to dedicate staff time to creating education material, especially projects with national or global presences. The needs and goals of informal educators are sometimes harder to define because they do not have the structural or mandated requirements possessed by formal education programs. The biggest obstacle to getting them to participate may be time for learning about a program and for becoming actively involved.

An interesting education group that sits between formal and informal are the master naturalist programs in a number of different states. These programs may establish partnerships with citizen science projects and use work on those projects as evidence toward becoming a master naturalist.

Having a group of promoters for citizen science is valuable but can also be a challenge. The number of steps between the public and scientists is relatively small for citizen science and that contributes to the ability of citizen science to change the relationship between public and science. Adding more people to the link may weaken the message or outcome of connecting a scientist and a volunteer. The most successful projects work hard to make sure that the connection between volunteer and scientist is established early and maintained throughout the project.

Mediation is a double-edged sword for citizen science. On the one hand it is very valuable to have a set of people who are promoting citizen science to the public in channels that do not depend on mass media. Additional channels make it more likely for the message about citizen science to reach interested members of the public. Some of the mediators, like parks and museums, may have existing infrastructure which can further support the growth of citizen science.

But the drawback of too much mediation is that the connection between scientists and public becomes weakened. If scientists become isolated by layers of activity then many of the benefits of citizen science projects may decline.

6.4 Legitimation and Extension: Persistent Challenges

One of the arguments being made in this dissertation is that citizen science is an response to previous claims against the legitimacy of scientific expertise. The critique of technology from the 1960s and 1970s, plus various social movements during the same period called into question the autonomy technoscience had gained after World War Two. Further developments over the next three decades contributed to this critique: postmodernism, the paradigm debates in the social sciences, the second wave of science studies, and debates about a risk society. By the 1990s science was taking an intellectual beating and struck back leading to the 'science wars' of that decade. The Sokal hoax and other efforts by science supporters tried to put radical social construction back in the box (Gross & Levitt, 1994; Sokal, 2008). Both sides in the science wars failed because they became too absolutist in their positions. Some radical postmodernists claimed that human reality was completely socially constructed while science supporters demanded that science be accepted as the best method for all human inquiry. Neither side is correct even if some of their criticisms are legitimate.

Citizen science is one example of a pragmatic solution which has taken the lessons of the science wars and combined them with movements for public understanding and public engagement with science. In this sense citizen science is a positive development for connecting the public and science more closely.

But the success of citizen science is not guaranteed, and may never be guaranteed because the boundaries between science and the public can always be renegotiated or recreated. Dewey argued that the nature of the public was a historical situation dependent upon the consequences of recent actions although it was also influenced by past social formations. The public arose in response to consequences of past actions. Likewise the public for citizen science arose, in part, because of the intellectual and social upheavals of the past 50 years.

Habermas may provide the most pertinent corrective to overactive enthusiasm about citizen science and the public. He diagnosed one of the key problems with modernity as a type of creeping scientism, the colonization of the lifeworld by rationalized systems. Science is one of the great sources of rationalization in the modern world and the current economic structure of global capitalism incorporates many of the technological advances provided by science before society or the lifeworld has an opportunity to reflect on the purpose of those advances. Is it possible that citizen science may be another form of colonization?

The answer to this question is complex because citizen science is many things in many different disciplines. Ornithology and astronomy have both historical and contemporary experience at making peace with amateur contributions. Ecology and environmental sciences are beginning to recognize the value of volunteer monitoring because they are desperate for the resources needed to monitor the global environment especially when faced with global challenges such as climate change. Other sciences may never incorporate volunteer efforts in a significant way because the resource costs

are too large to be borne by individuals. High-energy particle physics is one of those areas where volunteer data collection is impossible because particle accelerators are very expensive.

Even in scientific disciplines where volunteer help is desperately needed there is the potential for pushback when the topics being investigated run against economic or technoscientific interests. Citizen science includes many environmental monitoring projects where some results may be detrimental to economic or developmental concerns. In such cases the array of experts who are posed to testify in support of large companies, governments, and other powerful interests is still quite large. By claiming part of the social prestige of scientific methods a citizen science program can gain a foothold at the table for discussing environmental impacts. Citizen science can be co-created and used to move the public and science together toward mutual understanding.

The negative possibility of colonization also exists. The current vogue for discussions about big data in many different scientific and social fields is also a potential threat to the lifeworld. If every object becomes a sensor then there are no barriers to everything becoming part of a larger system subject to remote control. Citizen science could be co-opted into a larger system of surveillance and data collection. Speculating along these lines may begin to sound like a science fiction dystopia but the ethical challenges are real.

Collins and R. Evans (2002) identified two key problems in STS discussions around expertise: the problems of legitimation and extension. The former arose out of the

challenges to expertise mounted by the second wave of STS. The latter arose out of the problem of deciding how to manage in a world where expertise still matters but democratic decision making still needs the input of a diverse public. Citizen science deals with both problems. The first by accepting the role of science as a repository of expert knowledge. The second by opening the doors to allowing outside participation through the contributions of volunteers.

6.5 The Challenge of the Publics

Attempts to alter the public understanding of science have a long history. Popularization efforts have used the mass media since at least the 19th century to spread the results of science to a larger group of people who may be interested in the topic but not actually involved in the research process. Scientists played different roles at different times shifting back and forth the amount of time they devoted to public presentation (Lengwiler, 2008; Lewenstein, 1992).

One of the challenges of this interaction between science and public is defining who exactly the public is. Most of the discussions about public understanding or public engagement assume a relatively homogenous public. Laments about low scientific literacy are one prime example of this homogenous public in the minds of policymakers and scientists.

The literature on publics and social worlds suggest a much more complex picture. Instead of a single public there are many different publics with different interests and concerns about science and technology.

Dewey conceptualizes a public with direct positive ties to both democracy and inquiry. His description of openness and the value of democratic methods was a defense against opponents who were concerned about the massification of the public and whether the public could deal with the technoscientific issues which were beginning to arise at the start of the 20th century. He defended democracy and the right of the public to be heard whenever the consequences of an action could potentially effect it. Inquiry was key for the public in order to foster a reflective understanding. An understanding that could then respond to consequences through policy or government intervention.

Habermas presents a picture of the public sphere as a particular historical moment when private people intervened in government through public conversation and dialog. He argued that the mass media was a detriment to the idea of the public because there was no room for discussion or negotiation. Public opinion was being mass produced.

Technocracy and rationalization were key modern trends that contributed to the move from mutual understanding toward strategic rationalistic action. The colonization of the lifeworld by systems is a key contributor to government losing legitimacy in modern societies. Rebuilding a public in such an era is difficult but not impossible.

One of Fraser's main arguments against Habermas is over the idea of a singular public sphere. She argues that real societies are divided by social status and do not have unified publics acting to effect governments. Instead there are competing interests, multiple publics, who have different levels of access to power. Groups which are outside the circles of traditional political power may form counterpublics which support their own development and action. The concept is very similar to the idea of social worlds but with a political orientation toward democracy and participation in government.

How can each of these conceptions of the public be reconciled with citizen science?

The contemporary incarnations of the public understanding of science movement, especially as they arose in the United Kingdom during the 1980s, reflected a serious concern on the part of scientists that the public no longer supported or understood contemporary science. Reports and studies published at the time demonstrated the concern of policymakers and scientists (Gregory & Miller, 1998). The result was the formation of a Deweyan public which was constituted in response to a problem - the lack of scientific literacy among the public. The difficulty is that a public, even in the Deweyan sense, needs to go beyond the recognition of a problem toward self-recognition. If scientists are the only ones calling for a public then self-recognition is difficult to achieve.

Since then many more varieties of engagement by and with the public have come to fruition. A spectrum of engagement types have developed. A similar spectrum exists in citizen science. Projects can be classified on a spectrum of participation form

contributory to co-created. Technological platforms like the web allow volunteers to develop their own sense of identity and connection. All of these suggest that citizen science would fit many of the criteria for being a Deweyan public.

Achieving a public along the lines described by Habermas is more difficult. Recognition and self-reflection are not sufficient. For Habermas the quality of the interactions between people is crucial and forms the basis of his dialogic ethics. Communicative action depends upon people aiming toward mutual understanding without coercion.

On the face of it citizen science appears to meet the criteria of non-coercion. People are not being forced to participate in citizen science projects although the prospect of constant monitoring for the sake of big data may indicate a potential for aspects of coercion to shift in the future. The harder criteria to achieve is aiming toward mutual understanding. Co-created projects may be the best examples for where citizen science begins to achieve mutual understanding between scientists and the public.

The fragmented public presented by Fraser may be a more accurate description of current society than some of the idealizations of Dewey or Habermas. For Fraser the domination of public interests by particular classes or economic wealth may lead to the creation of counter-publics in opposition. Citizen science could be a counterpublic within the scientific establishment, an offshoot which is protesting the current relationship between science and the public. Such a view begins to suggest potential parallels between citizen science and social movements.

Fragmentation on the part of the volunteer audience is one reason why recruitment for citizen science is so difficult. People are engaged in their own social worlds. Mass media, which may have bridged those worlds in the past, is now fragmented by economic and technical changes. At the same time the number of people willing or able to dedicate time to volunteering for a citizen science project may always have been and always will be small. The problem shifts from lack of access to preaching to a choir.

One speculative way to overcome this difficulty may be to emphasize the citizenship part of citizen science. If participating becomes an obligation of being a citizen in a larger community then the potential number of volunteers increases dramatically. But for the citizenship option to work well it also needs to be reciprocal. Obligations to contribute to the collection or analysis of data need to also turn into rights to determine the course of research and the application of technology.

At such an extreme end citizen science may be the start of a revolutionary reimagining of the relationship between science and the public. We are only seeing the earliest glimpses of such changes but the future may have more surprises in store.

Chapter 7

Conclusion

The original research questions posed by this dissertation covered two major areas of investigation. First, there was the question of how citizen science is currently being framed and the creation of those frames by various groups of people involved in citizen science. Second, was the question of if citizen science is affecting the relationship between the public and science, and if so how that relationship was changing.

The results for the framing question show that citizen science is not currently being framed using widely established historical frames from science communication. New frames are being proposed by some of the groups involved in citizen science but those frames have yet to be adopted by the media. When it comes to the impact of citizen science on the relationship between science and the public there are suggestive hints that citizen science is changing that relationship but more evidence will need to be gathered in order to substantiate these social impacts of citizen science.

The following sections of this chapter recap the major contributions of the dissertation to current conversations in various fields from communication to science and technology studies. A number of limitiations are described for the current research and future directions for expanding and supporting the conclusions of this dissertation are suggested.

7.1 Contributions

This dissertation contributes to four major questions which cross multiple disciplinary boundaries in science and technology studies, communication, information science, and citizen science itself.

First, the current dissertation presents an intellectual account which places citizen science into a context of intellectual and social movements stretching back to the 1960s. A combination of social and intellectual movements beginning in the 1960s began to question the role of technoscience in the modern world. Student, environmental, anti-nuclear and many other social movements continued these debates into the 1980s. Contemporary examples of social movement resistance to technoscience include the campaigns against vaccination and genetically modified organisms. At the same time intellectual movements questioned technoscience from a variety of perspectives. Habermas and other social theorists argued against excessive scientism and rationalization in Western culture. Technology critics like Winner, Ellul, and Mumford debated the amount of control people have over the growth

of technology. Postmodernists questioned the value of grand narratives while STS scholars developed a critique of objectivity in science.

Citizen science as an intellectual movement arose in the 1990s. Alan Irwin incorporated the latest developments from STS and the study of risk perception into a call for more ways for people to participate in technoscientific decisions. He called this movement citizen science. Rick Bonney and other colleagues used the term citizen science to describe the growth of public data collection and analysis in the sciences. Technical developments, such as the World Wide Web and the internet, enabled these nascent experiments in voluntary data gathering to flourish and become the citizen science we see today.

Second, the current dissertations uses developments in the study of communication frames to look for current frames used to describe citizen science and examine how those frames are being created, altered, and distributed through the media. Over the past two decades science communication scholars have increasingly focused on a key paradox in public understanding of science. More efforts to educate the public about key issues, such as global warming or evolution, do not seem to have an effect on the perceptions of the public. An explanation for this effect in communication framing studies has been proposed which suggests that people are more receptive to science stories which are framed to be congruent with their emotions and prior experience.

The dissertation looked for a standard set of science communication frames used to described citizen science to the public through the media. The results suggest that current standard sets of science communication frames may be limited for a number of

potential reasons including the genre structure of news reporting, structural changes in science journalism, and the focus of many past studies of science framing on publicly controversial topics. The novelty of citizen science means that the media is still trying to decide how to frame it for the public. People already involved with citizen science such as researchers and project staff focus much of the communication on the topic of education and expanding the access of people to scientific research. Journalists and writers on the periphery of citizen science describe it as a new name for hobbyist activity or environmental action. The overall portrayal of citizen science is positive.

The third contribution of the current dissertation is description of the competing values and traditions which lay at the center of citizen science. The instrumental-pragmatic view of citizen science as a way to meet the challenges of current scientific research by distributing the task of data collection and analysis to a wide audience is the on major paradigm for the presentation of citizen science to the world and to itself. The emancipatory-participative view of citizen science as a way to reform the relationship between the public and science by incorporating citizens in the design and performance of scientific research is another major paradigm. The different paradigms can be seen in the self-reports of researchers and project staff involved in citizen science. It can also be seen in the multiple activities which are incorporated under the banner of citizen science by the media including crowdfunding, volunteerism, open-access, the wisdom of the crowd, and filling environmental gaps. The confusion of the media reflects a social world which is still debating the future direction of citizen science.

Fourth, the current dissertation begins to offer some criteria for judging the role of citizen science in the ongoing relationship between science and the public. It begins by complicating the notion of the public in order to go beyond the normal cliches of science communication which still often speak of the public in the singular. The public is multiple and has many different concerns about technoscience. The social world perspective of citizen science shows a graded transformation and exchange between insiders, regulars, travelers, and outsiders. Media stories are one of the boundary objects which facilitate the exchange between these different groups. Key organizational roles transform scientific protocols into teachable education modules for classroom and informal activities. Mediation succeeds in opening science to a potential audience by creating communication channels between scientists and the public.

The boundary between scientists and the public is a combination of professional separation and expert experience. The historical role of amateurs for negotiating the boundary between science and public suggests that citizen science may have a promising future by opening up the possibility of co-created science for the future.

7.2 Implications for Citizen Science and Media

The results of this project lead to some practical recommendations for aiding citizen science projects with their outreach to the public and relations with the media.

- Align the news cycle and the project cycle. There are two key moments when citizen science projects can gain publicity. First is the announcement of the project. Announcing a project before it is able to accept volunteers may be a waste of resources and attention. Better to capitalize on the announcement for maximum recruitment. Second is when reports or results are published.

- Keep a list of local volunteers who may be interested or available to promote a project to the media. Most media is based on local interests and having a community connection who is available for quotes and information is important. A potential group to recruit for this role are the 'super-volunteers' who are already contributing significant time to a project.

- Balance the discussion between education and engagement. Too much emphasis on education is potentially detrimental, especially to the emancipatory-participative aspects of citizen science. Overemphasizing education may perpetuate the deficit model of public understanding. Better to figure out how the project engages the community in addition to just teaching them about science.

- Build a robust communication strategy which goes beyond mass media channels. Attention from the mass media is a scarce resource so a robust communication infrastructure must include other channels such as internet websites, email lists, discussion boards, video channels, and social media presence. These channels allow a project to reduce the amount of mediation between scientists and

volunteers. Frequent communication between scientists and volunteers is one element of a successful project.

- Consider a strategy to extend the status of expertise to volunteers. Include participants in the credits for published articles or other outcomes. Think hard about other forms of recognition which may be valuable to volunteers.

7.3 Limitations

The limitations for the current research are rooted in two major areas - temporal limits and sample limits.

The temporal limits focus on the content analysis section of the evidence provided in this dissertation. Newspaper articles and press releases were only analyzed for the last 6 months of 2013 and the first month of 2014. This created some biases in the scientific topics which were covered such as the significant presence of ornithology in the type of sciences mentioned in the newspaper articles. The predominance of ornithology reflected a number of articles about the Audubon Society's Annual Christmas Bird Count. The annual count has been in existence for over a century but only recently has it been promoted as a citizen science project by the Audubon Society.

The research was unable to provide any information on changes in the framing of citizen science over time because of the small window of articles which were collected. Nor was there a chance to identify any numerical trends in the growth of citizen

science as reported in the print news media collected. Limiting the content collected to two databases - Lexis-Nexis and Eurkealert - may lead to some missing data in the media analysis section, especially any coverage of citizen science on radio or television.

Sample limits are primarily found in the interview data collected for this dissertation. Only 10 people were interviewed in order to provide first-hand data on the social world of citizen science. This interview data was supplemented by the academic literature reviewed and the analysis of content discussed above. The interviews did succeed in covering three different roles within the citizen science communication system - researchers, project staff, and writers. The original proposal included public information officers at universities who may have been called upon to produce press releases for citizen science projects. Unfortunately the limited time available for data collection prevented the inclusion of any subjects from this group which is often underrpresented in the study of science communication.

7.4 Future Directions

The results reported in this dissertation suggest a number of future studies which could continue the current research trajectory and also some ideas which may expand the trajectory into adjacent areas of inquiry.

An immediate area for future improvement would be extending the number of newspaper articles studied further back in time in order to detect changes in the framing of citizen science over time. The search for media artifiacts could also be

extended into other media such as radio or television in order to broaden the study of how citizen science is being framed for the public. A similar extension of the interviews would be to fill the gap with public information officers and increase the numbers of people from the roles of researchers, project staff, and writers. These extensions would expand the warrant for the conclusions presented in this dissertation but would probably not change the conclusions significantly. Expanding the survey of newspaper articles would also help to address the question of when citizen science stories appear in the media. The current results suggest that status changes such as the announcement of a new project, or new findings are key times when news attention can be found. A fuller comparison of frames between citizen science and more controversial topics might illuminate this situtation further.

There are also areas within in this dissertation which are underdeveloped and could be expanded. One of these is the use of social and philosophical theory in order to develop a deeper analysis of the social consequences of citizen science. The analysis of social consequences is a significantly underdeveloped area of inquiry in the study of citizen science. A fuller set of theoretically informed criteria for evaluating the social impact of citizen science is significant future direction of this research.

There are also adjacent areas within STS and communication studies which are undeveloped within the current study. The discussion of the relationship between citizen science and infrastructure is alluded to on a few occasions but left undeveloped. The implication of the absence of major science communication frames used to discuss

citizen science also need further development in order to test the conclusions and suggest possible reasons.

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Appendix

Appendix A

Interview Material

A.1 Interview Guide

Section 1 - Demographics

1. Name
2. Age
3. Sex
4. Occupation
   (a) Title
   (b) Place of employment
   (c) Years at this position
   (d) Previous positions

5. Education
    (a) Highest level
    (b) Major or area of specialty

Section 2 - Question Categories, Grand Tour Questions, and Planned Prompts

Citizen Science Background and Experience

1. Tell me about your first encounter with citizen science.
2. What terms for citizen science have you heard?
    (a) For example Public Participation in Research, volunteer monitoring, volunteered geographic information
    (b) How did you hear about citizen science?
    (c) Who told you about it?
    (d) How did they describe it?
3. Tell me about your current involvement with citizen science.
    (a) What attracted you to the project?
    (b) How did you participate in the project?
4. Tell me about your ideal citizen science project.
5. How should a citizen science project work?
    (a) What should be its goals?

(b) Who should participate?

(c) Who should manage the project?

Communication and Information practices

1. Tell me about how you communicate on your current project.

    (a) How did you communicate with Y

    (b) scientists,

    (c) project admins,

    (d) press officers,

    (e) funders,

    (f) other researchers,

    (g) administrators,

    (h) journalists,

    (i) volunteers

    (j) What kind of information did you exchange with Y?

    (k) How often did you communicate with Y?

2. What is the biggest challenge for project X?

    (a) What do you think about accuracy in citizen science projects?

    (b) How can accuracy be encouraged?

(c) How can accuracy be measured?

Role and Place of Citizen Science

1. Tell me how you describe citizen science to people who are hearing about it for the first time.
   (a) What do you think is the purpose of citizen science?
   (b) Why is citizen science important?
2. Tell me about the future of citizen science?
3. What is the most difficult thing about citizen science?
4. Tell me what you like about citizen science?
5. Tell me what you dislike about citizen science?
6. How would you describe the perception of citizen science in the press/public?
7. How has citizen science changed the way you conduct your research?
8. What does science mean to you?
9. What do you consider to be the ideal relationship between science and the public?
10. What is the role of democracy in scientific decision making?
11. How does the current relationship between science and the public differ from the ideal you described?

12. How does citizen science influence the relationship between science and the public?

13. What do you consider to the be the major achievement of project X? of citizen science in general?

A.2 Recruitment Email

Dear Mr./Mrs./Dr. xxxx,My name is Todd Suomela, and I am a researcher at the University of Tennessee Knoxville in the College of Communication and Information Science. I am currently recruiting participants for my dissertation project on communication in citizen science projects.The study focuses on the communication and information exchanges between scientists, project managers, public relations offices, and journalists. If you agree to participate, the interview would consist of talking with me for about 30 to 60 minutes. The interview will be recorded and later transcribed for analysis. Interviews can be conducted by phone or by Skype.

The identities of participants are kept confidential, and this study has been approved by the universitys institutional review board. Participants must be over 18 years of age. If you or someone you know is interested in being interviewed, you can contact me via email at the following university email address: tsuomela@utk.edu

If there are any questions you may have about the study or participating, please feel free to send a note. If you know of someone that may be interested, feel free to pass this note along and have them contact the researchers directly. Thank you!

A.3 Coding Frame

1. Call to action
2. Effects
3. Frame
    (a) Conflict-Strategy
    (b) Econ Dev Competition
    (c) Middle Way
    (d) Morality Ethics
    (e) Public Accountability
    (f) Runaway Science
    (g) Social Progress
    (h) Uncertainty
4. Genre
    (a) Announcement
    (b) Opinion-Editorial
    (c) Profile
    (d) Report
5. Geographic Scope

(a) Global
(b) Local
(c) National

6. History
7. Interview Themes
   (a) Funding
   (b) Future
   (c) Media
   (d) Needs
   (e) Networks
   (f) Resources-Time
8. Label
9. Objections
10. People
   (a) Educator
   (b) Other
   (c) Policy Maker
   (d) Project Manager

(e) Scientist

(f) Spokesperson

(g) Student

(h) Volunteer

11. Project Information

    (a) Goal

    (b) Name

    (c) Sponsor

12. Quote

13. Themes

    (a) Activism

    (b) Amateurs

    (c) Charisma

    (d) Citizenship

    (e) Communication

    (f) Defining Citizen Science

    (g) Education

    (h) Expertise

(i) Participation

(j) Publics

(k) Recognition

(l) Scale

(m) Science

(n) Technology

(o) Verification

14. Type of Science

    (a) Astronomy

    (b) Environment and Ecology

    (c) Historical

    (d) Medicine

    (e) Ornithology

Vita

Todd Suomela was born in Minneapolis, Minnesota. In high school he planned to become an astrophysicist. At Yale University he studied English and philosophy to complete his double major in 1994. For 10 years he worked in various jobs including corporate information technology. He returned to academia for a master's degree in information science from the University of Michigan. He completed his education with a Ph.D. degree in communication and information from the University of Tennessee.

His major research focus is the interactions between experts and non-experts. He is currently focusing on citizen science as a case study for interactions between professional-expert scientists and volunteers. His dissertation investigates the framing of citizen science in the national media and how these frames are being created by different stakeholders.

He has presented research at various conferences such as BOBCATSSS, ALISE, and Society for Social Studies of Science. He has published research on the data management practices of astrobiologists and the history of crowdsourcing astronomy in the nineteenth century.