Using Visual Media to Empower Citizen Scientists: A Case Study of the Outsmart App

Using Visual Media to Empower Citizen Scientists: A Case Study of the Outsmart App

A Thesis Presented

by

MEGAN KIERSTEAD

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ABSTRACT

USING VISUAL MEDIA to EMPOWER CITIZEN SCIENTISTS: A CASE STUDY OF THE OUTSMART APP

SEPTEMBER 2019

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To be successful citizen science projects need to do two key things: (1) they need to meaningfully engage the public and they must also provide people with the tools, expertise, and/or training needed to participate in rigorous research that can be used by the scientific community. In some ways, these requirements are potentially at odds. Emphasis on rigor and expertise risks excluding members of the public who do not feel qualified to participate in esoteric or technically difficult scientific research. Conversely, projects that eschew rigorous methods in favor of wider participation might lead to bad data that cannot be used to draw any meaningful conclusions to expand scientific understanding. How then do those who are aiming to design successful citizen science programs create tools and processes that facilitate both active engagement and meaningful scientific results for perceived non-expert researchers?

This paper uses a case study of the Outsmart Invasive Species Project (Outsmart) to explore how visual media shape the experiences of citizen scientists participating in a data collection project. Outsmart uses visual media such as photographs and videos to train users in identifying invasive species, and asks them to submit their own location-tagged pictures to a central database for review by a trained research team. Using ethnographic field observation, we focused on how visual media serve to improve engagement in non-expert Outsmart users by building confidence and expertise. Our work can provide guidance to other citizen science projects in how to best use visual media to empower citizens and improve scientific outcomes.

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CHAPTER I

THE TENSION BETWEEN RIGOR AND ENGAGEMENT IN CITIZEN SCIENCE

A. Introduction

Researchers have realized something incredibly powerful about the public: the wider populace has the ability to meaningfully participate in scientific discovery to both widen the scope and impact of research and collect vast amounts of data at very low costs (Carolan 2006; Nov, Arazy, & Anderson, 2014; Whitelaw, Vaughan, Craig, & Atkinson, 2003). “We can't afford [professionals],” says Donald Owen, an environmental protection specialist with the National Park Service (NPS). “We can't get enough research assistants to do what we can get [amateurs] to do. Not even close” (Cohn 2008). Scientists have thus decided to harness the hands and minds of citizens in a dizzying array of endeavors, including bird watching (Khoury et al., 2014), galaxy classification (Raddick et al., 2010), protein folding (Sullivan et al., 2009), climate change (Cohn 2008), maps (Haklay & Weber, 2008), population ecology (Peterjohn & Sauer, 1996), and many more.

To be successful, however, these “citizen science” projects need to do two key things: (1) they need to meaningfully engage the public, so that people will want to actively participate and contribute as unpaid volunteers; and (2) they must also provide people with the tools, expertise, and/or training needed to participate in rigorous research that can be used by the scientific community. In some ways, these requirements are potentially at odds. Emphasis on rigor and expertise risks excluding members of the public who do not feel “qualified” to participate in esoteric or technically difficult scientific research. Conversely, projects that eschew rigorous methods in favor of wider participation might lead to bad data that cannot be used to draw any meaningful conclusions to expand scientific understanding.

How then do those who are aiming to design successful citizen science programs create tools and processes that facilitate both active engagement and meaningful scientific results for perceived non-expert researchers? Designing these programs to be inclusive and productive can be incredibly difficult, especially with a diverse set of stakeholders at different skill levels: citizen science projects should ideally not only help researchers achieve scientific goals, but empower those who volunteer their time and skills without expecting anything tangible in return.

I see visual media, such as photographs and videos, as the potential bridge between experts and the public. Their permanency reduces training burden, their universality can eliminate jargon and language barriers, and they help tell stories that appeal to wide swaths of the human experience. In short, visual media have the potential to help those who are creating citizen science programs with both of the crucial issues of engagement and scientific rigor.

This thesis uses a case study of the Outsmart Invasive Species Project (Outsmart) to explore how visual media shapes the experiences of citizen scientists participating in an ecological data collection project. First, I present the research questions that form the basis of this study. Second, I describe Outsmart, the project that is the context for this work. Third, I summarize the important foundational concepts and literature relevant to undertaking this research. Fourth, I discuss the methods used to investigate the above research questions, and, fifth, I present the results organized by emergent theme. Finally, I discuss the wider implications for citizen science research and bridging gaps between scientists and the public.

B. Research Questions

Below are the two research questions that I investigated using qualitative mixed methods on a single case study.

- How do visual media, such as photographs and video, compare to language-focused resources (e.g. text, verbal) for citizen scientists?
- Does the act of creating visual media and contributing it to a project feel empowering to a citizen scientist?

My case study utilized my involvement in Outsmart, which is an invasive species monitoring effort in New England that utilizes crowd-sourced data from smart phones.

1. Outsmart – An Invasive Species Citizen Science Mobile App as a Case Study

To understand the context of my work, it is necessary to place Outsmart within the framework of invasive species citizen science programs. These projects have many advantages over traditionally small conservation teams; they can have many more people looking, with repeated observations, over a vast geographic scale – potentially recognizing and eliminating species before they establish footholds (Bonney et al., 2009). Some species, in particular, can be difficult or even impossible to eradicate once they become established (Fitzpatrick, Preisser, Ellison, & Elkinton, 2009). Scientists have recognized, "monitoring programs aimed at detecting low-density 'founder' populations can play a critical role in slowing or even stopping the spread of harmful invasive species by identifying recently established populations that can be targeted for control and/or eradication" (Lodge et al., 2006). Given invasive species threaten biodiversity, destroy native ecosystems, and cost countries billions to eradicate and control each year, the economic and ecological impacts are potentially immeasurable (Lodge & Shrader-Frechette, 2003; Pimentel, Zuniga, & Morrison, 2005; Stohlgren et al., 1999).

a. How Outsmart Works

To this end, the Outsmart Invasive Species project uses citizen science volunteers equipped with smartphones or digital cameras and asks them to identify and report invasive plant and insect data on their own time. Users submit their reports through the Early Detection and Distribution Mapping System (EDDMapS) website (www.eddmaps.org) or through the smartphone app called "Outsmart Invasive Species" (Outsmart; http://masswoods.net/outsmart). The species are limited to a specific subset of invasive species in New England (Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine), with a particular focus on Massachusetts and on the early detection of new or emergent threats. Outsmart is a collaboration between the University of Massachusetts-Amherst, the Massachusetts Department of Conservation and Recreation (MA DCR) and the Center for Invasive Species and Ecosystem Health at the University of Georgia.

Working with these partners, the Outsmart team identified twenty-two plant and five insect species that fall into three general categories:

(1) "High priority, early detection": Species that are not yet established in MA, but have been found in neighboring states and pose a considerable threat. If found, some management measures may be taken to prevent establishment;

(2) “Early detection, established”: Species that already exist in some areas of MA, but could still be potentially controlled; and,

(3) “Established invasive”: A species that is well established in MA, but the information collected through Outsmart could be useful for a better understanding of its geographic distribution.

In addition to a text-based field guide for each of these invasive species in the mobile app, Outsmart uses visual media such as photographs and videos to train users in identifying invasive species, and asks them to submit location-tagged pictures (with the location automatically supplied by a smartphone’s GPS, if available) to a central database for review by a trained research team. The app feeds the broader web-based database system, EDDMapS. Figure 1 describes the data flow process.

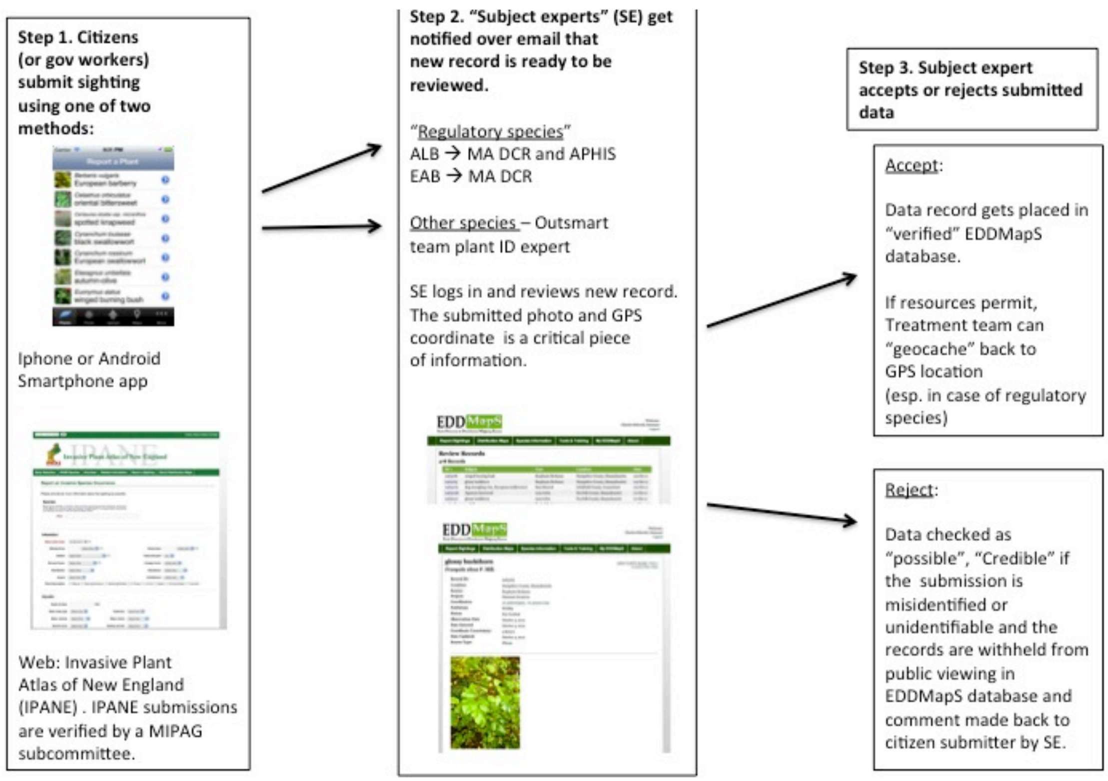

Figure 1: Outsmart Data Flow

b. Outsmart Submission Process

First, (not shown in Figure 1) citizens need to decide how they intend to report their invasive species data. They can either download the free Outsmart app from the Apple Store (if they have an iPhone or iPad) or Google Play (if they have an Android phone or tablet). Alternatively, they can also upload digital photos and other data using the EDDMapS website on their computer. After they have set up their account, citizens can go to the field and look for invasive species.

Once they discover a potential invasive plant or insect, they can report data (Step 1, Figure 1: Outsmart Data Flow). Data submitted includes a photo of the plant or insect, GPS location (or pinned location on Google Maps if they are using the web interface), and other information such as extent of the outbreak, the date and time submitted, and the user (including email address) who submitted it. The information is uploaded to the EDDMapS database at the University of Georgia.

In Step 2 (Figure 1: Outsmart Data Flow), EDDMapS is designed to automatically notify designated “subject experts” (SE) depending on the species reported. In the case of two “regulatory species” -- Asian Longhorned Beetle and the Emerald Ash Borer -- emails are also sent to government officials at the Animal Plant and Health Inspection Service (APHIS) and MA DCR who are responsible for the government response when a sighting is reported. In the case of non-regulatory species, plant identification experts on the Outsmart team are notified.

In Step 3 (Figure 1: Outsmart Data Flow), subject experts login to EDDMapS via a web-interface to review the submitted data. The digital photo submitted with each report is crucial, since often the SE can make a positive, confirmed identification of the invasive. Through this review the SE either marks the record as:

(1) "Verified" when it is clear that the citizen correctly identified a species;

(2) "Credible" when the reported species is unidentifiable based on the submitted image but was submitted by a user who has a track record of submitting correct data, or

(3) "Possible" if the submission is unidentifiable or likely incorrect based on the submitted image.

The SE will communicate the outcome in comments, and is likely to contact the reporter with any issues, especially if the citizen has made an incorrect identification.

Records marked as "credible" or "possible" are not made public via EDDMapS. At review time, subject experts can specify whether "verified" records are made visible to the public through the EDDMapS web-based "distribution maps", or treated as private. The responsible government authority will act on reports of verified regulatory species. At this juncture, responses to a verified plant species outbreak at a location are fairly limited due to lack of resources; however, this issue of how to respond to a verified outbreak is currently being discussed by Outsmart's collaborative partners (MacDonald et al., 2012).

c. Why Outsmart as a Case Study?

Outsmart makes an ideal case study for an investigation of visual media in citizen science because of the abundant use of visual media within the app, during both identification and the reporting process, as discussed above. Each species has a number of photographs and diagrams illustrating important plant features to help a user identify the plant (See Figure 2: Photograph in Outsmart app that helps users identify glossy buckthorn plant). Some species even have quick, pithy videos pointing out specific features, lookalikes, and tips for identification. Additionally, plant identification is a difficult task that requires expertise, so working with Outsmart users allowed me to really see if non-experts would find benefit from the visual cues and reporting process the app provided.

Figure 2: Photograph in Outsmart app that helps users identify glossy buckthorn plant

CHAPTER II

USING VISUAL MEDIA TO IMPROVE CITIZEN SCIENCE

A. Visual Media as Shared Understanding

Why are photographs, videos, and other visual media such potentially powerful tools in citizen science and other technically complex contexts? I would argue that some of their power comes from visual universality in a world that often relies on linguistic meaning to communicate. Language is incredibly contextual: it does not necessarily translate easily across cultures, countries, or education levels. Photographs are certainly contextually situated (and subject to one's own cognitively biased interpretation), but their meaning is more shared than language. People can share photographs and diagrams when they do not speak the same language, or even if they cannot read at all.

B. Language as Means of Exclusion

Unfortunately, scientific communication often relies on the linguistic skills of scientists who cannot translate to those outside their culture: these scientists all speak the same contextual language. Because language is contingent and shaped by the community of practice from which it emerges, the terms and jargon used by scientists and researchers are not easily understood by outsiders (Yanow 2006). Typically, one has to belong to a specific scientific community (either formally or informally) before one is able to understand and interpret its meanings. If one has ever listened in on a technical conversation in a field one is entirely unfamiliar with, it can actually sound like a foreign language – that is because in some ways, it is. This "foreignness" is particularly problematic when one considers that their fellow researchers will often require years of education before they consider them a "legitimate member" of the scientific community.

C. Meanings Differ Between Communities of Practice

Even if two people are both well established enough to be card carrying scientists and happen to both speak, say, English, if they are from a different scientific communities of practice (e.g., Ecology vs. Anthropology), they could mean something very different using the exact same word (e.g., "community"). As an example, Adams et al. found this to be a serious risk when ecologists were speaking to laypeople. The ecologists would use words like "stability, productivity, pioneer, and exploitation" without explaining that these terms have very specific meanings in ecology that differ from typical English use, leading to wide misunderstandings of environmental literature (Adams, Di Bitetti, Janson, Slobodkin, & Valenzuela, 1997). Diagrams and photographs to illustrate these concepts would have gone long way toward clearing up this linguistic confusion.

D: Sometimes Visual Media Can Better Capture Meaning

Sometimes language is not just confusing, however; it cannot accurately capture nuances as well as visual media can – especially when non-experts lack the vocabulary to describe a particular phenomenon. As an example of this, in a study, 49 nurses used a variety of documentation formats, including photography, to capture clinical findings to manage and assess a wound over time. A wound that might be exhibiting subtle changes in shades of red would be written down as "inflamed", especially if the person documenting the visuals lacked the expert vocabulary to describe the wound in more detailed terms. By using photographs to document the changes instead of words, these nurses were able to accurately use visual cues to compare clinical findings from the past to the present. These researchers concluded that photographic evidence may be able to bridge the gap between novice and expert nurses because differences in vocabulary and expertise were ameliorated through shared visual understanding (McGuiness & Axford, 1997).

E. How is a citizen scientist different from a scientist?

Understanding how to bridge knowledge gaps between novices and experts is critical for citizen science programs as well, since it is unlikely that all the citizens and all the scientists involved in a particular project have the same level of expertise. In fact, one of the key assumptions underlying the idea of citizen science is that there is a difference in expertise between the citizen and the researcher. The idea is reified in the name itself, since "citizen science" is somehow different from "science". Certainly, the design of citizen science projects differs from traditional research projects, with a clear divide between the data collectors (the citizens) and the analysts (the researchers) in both role and perceived expertise. The expert scientist is the one who designs the citizen science program: its goals, its methodology, and how the data collected will be used. While there are some efforts to involve the public throughout the scientific method, on the whole, the research establishment is still concerned that the public does not have the skills to meaningfully contribute to research design and analysis (Fortmann 2009).

F. The deficit model of public participation in science

Some anthropologists have formalized this belief through the "deficit model of public participation", which states that the average citizen is unable to understand and appreciate the accomplishments and practices of the scientific establishment because of gaps in scientific literacy and misrepresentations in the mass media (Wynne 1991, 1995). Unfortunately, it likely the experts themselves who reinforce and perpetuate the idea that the public lacks knowledge or expertise. As an illustration, during a study on communication between doctors and their patients, researchers administered a quiz to the patients to estimate their medical knowledge, while also asking the doctors to assess the same patients' medical knowledge. The patients did quite well, scoring an average of 75.8% on the quiz. The doctors, however, were not able to assess their patients' medical knowledge accurately, with 41% underestimating their patients' comprehension. Perhaps more alarmingly, even after being informed of a patient's savviness or lack thereof, a doctor would not adjust his or her communication style (Segall & Roberts, 1980). This study raises the possibility that because experts are sometimes so unwilling to engage with those who are lacking expertise, they are perpetuating others' "ignorance" and reinforcing the existing barriers between the public and those with specialized knowledge.

G. Are Citizen Scientists Less Useful?

Certainly, other researchers and scientists disagree with the deficit model of public participation, claiming that lay knowledge is a useful form of expertise unto itself:

> "Lay knowledge is not an impoverished or quantitatively inferior version of expert knowledge; it is qualitatively different. Factual information is only one ingredient of lay knowledge, in which it interweaves other elements (value judgments, trust in scientific institutions, the person's perceptions of his or her ability to put scientific knowledge to practical use) to form a corpus no less sophisticated than specialist expertise" (Bucchi & Neresini, 2007).

Using this trust and these perceptions, citizens bring their wisdom, enthusiasm, and other forms of knowledge to citizen science projects, which can benefit outreach and awareness, among other factors. Additionally, there is some evidence that citizen scientists can be almost as accurate as trained scientists, especially for some tasks. One study of the Illinois EcoWatch Network found no difference in skill between volunteers and botanists for 12 out of 20 easily identifiable tree and shrub species, but volunteer accuracy rates suffered on more difficult flora (Brandon et al., 2003). Another study trained novices in bird song identification and then found no difference in their identification skills versus experienced birders on a set of chosen species (McLaren & Cadman, 1999).

Even with this evidence, data quality is still one of the most universally discussed issues in citizen science because some researchers believe laypeople do not have the training or knowledge to collect the data in an unbiased, accurate, or precise way (Brandon, Spyreas, Molano-Flores, Carroll, & Ellis, 2003; Cohn 2008; Dickinson, Zuckerberg, & Bonter, 2010). In 30 semi-structured interviews with British scientists who had direct experience participating in a large-scale citizen science project, Riesch and Potter found that data quality was a "clear area of worry for the majority of interviewees" and even if researchers were not concerned themselves, they worried about the perceptions of their peers (Riesch & Potter, 2014). There also has been some evidence of wide variance in the level of oversight in data collection, training, and monitoring, even within established programs, which only adds to scientists' trepidation (Penrose & Call, 1995).

To ameliorate these issues with data quality in volunteers, researchers have identified a number of strategies:

-Provide training or close supervision (Cohn 2008),

-Review related literature to see if results are reasonable,

-Crosscheck volunteer observations with scientist observations,

-Give quizzes at the end of data entry, or

-Simplify the tasks or research questions (Riesch & Potter, 2014).

H. Visual Media as Aids to Help Experience-Based Experts

Because the public is incredibly diverse in skillsets, representing a wide range of age groups, cultures, technological aptitude, languages, and education level – experts must find ways to engage with them if they want to create citizen science programs that succeed (Newman et al., 2010). As an example, in March 2008, the Center for Nanotechnology in Society at Arizona State University held the National Citizens' Technology Forum (NCTF) on nanotechnology and human enhancement (for details see (Hamlett, Cobb, & Guston, 2013)). Researchers found that the diverse participants, who were widely representative of the demographics in the United States, were able to grasp the technical aspects of nanotechnology and discuss meaningfully the complexities of equity and societal impact these potential innovations might have on their communities by using mixed media, including photographs, even when they did not possess a technical background or degree (Guston 2014)

Of course, not all members of the public are lacking in "expert" knowledge solely because they do not have certifications or degrees. Their wisdom comes from a wealth of learned experience. Collins and Evans call these people "experience-based experts" (Collins & Evans, 2002). They might just lack the language or group membership conferred by formal education.

Ideally, this is one area where visual media in citizen science projects might help: experienced-based experts can use visual media as memory aids, allowing them to recall a concept or situation (Gubrium & Harper, 2013). They can use diagrams, photographs, and videos as quick, easy, and accessible aids to help them complete whatever task the citizen science project has laid out for them. Since the visual media is recognizable, it will not alienate them or cause them to lose confidence in their abilities. This can be empowering and a potential source of learning, if the images are eventually tied to new terms or tasks.

Additionally, if citizen science projects empower individuals to produce and take ownership of visual media within their communities, they might also give these people social capital within their social groups. For example, the young indigenous producers of new media in Aboriginal Australia disrupted the oral, geographically rooted authority within their villages with their access to new forms of information (Michaels 1985). This is especially powerful if this media can be shared. Even if someone intends to film or photograph something for the purposes of documentation, the use of these visual media is very often a social act of communication. A real estate agent takes photos to document the details of the house they wish to sell; a newspaper photographer takes a picture to document an important current event; a contractor documents the before state of a room that they are going to remodel (Banks 2008). Images can provide new understanding, collaboration, and create shared meaning between groups of people who might otherwise have not communicated.

CHAPTER III

OCULARCENTRISM AND THIS THESIS

It is unsurprising that visual media can play such a key role in citizen science. According to Banks, we are an "ocularcentrist" society (2008). Ocularcentrism is the privileging of sight above all other senses. He hypothesizes this phenomenon exists because the media bombards us with an overwhelming volume of images every day. He rightly observes the irony, however, that even social researchers interested in visual media are surprisingly unreflexive—still preferring the written word to images to communicate their ideas. I absolutely acknowledge that I would be uncomfortable submitting this thesis entirely in visual form -- both because of my own skill with media, and my concerns about the reception from my thesis committee.

CHAPTER IV
METHODS

A. Participant Observation Recruitment and Setup

1. Outsmart Experiment as a Starting Point

During the summer and fall of 2013, the Outsmart team ran an experiment to test the relative success of in-person training versus video and image/text-based training for plant identification (see results in (Starr et al., 2014)), which formed the context of my work. I was heavily involved in the design and implementation of this particular experiment, so it was a logical jumping off point for my own case study of Outsmart users. In fact, my participant observation fieldwork was watching students partaking in the experiment, so it is necessary for me to describe the Outsmart experiment in detail.

The Outsmart experiment needed consistent materials for all three training modalities (in-person, video, image/text), which were developed with a regional expert, Ted Elliman from the New England Wildflower Society (newenglandwild.org), and imagery available from the University of Georgia's Bugwood Image Database System (http://images.bugwood.org/). To eliminate potential error from using different language for the different training groups, the Outsmart team aimed to keep the in-person, video, and text scripts as consistent as possible. The Outsmart app contains key characteristics at the top of the page followed by species description, seasonal developments, look-alikes, and ecological threat, as well as pictures.

Students in three Natural Resource Conservation courses at the University of Massachusetts Amherst were recruited to volunteer before September 30, 2013. All volunteers were directed to complete an online survey in order to participate in the study.

The survey was designed using Survey Gizmo, a web-based survey design tool (surveygizmo.com) and was pre-tested with colleagues and students.

In the survey, students were first asked for basic demographic information (gender, age, education level) and how they had heard about the experiment. Then, participants were asked to self-identify their plant identification experience level as "No experience", "Beginner", "Intermediate", or "Advanced". The survey provided no clarification about these terms, so participants could interpret these skill levels however they so desired. Participants who identified as "Beginner" "Intermediate" or "Advanced" were asked an additional two questions. The first question asked them how they learned their plant ID skills. The second asked if they could specifically identify, without aids, the five species used in the experiment.

Upon completing the survey, the students had an equal chance of being randomly assigned to one of the three training modalities. These instructions were displayed immediately as a webpage and emailed (see APPENDIX A

IN-PERSON TRAINING - EXPERIMENT INSTRUCTIONS, APPENDIX B

VIDEO TRAINING - EXPERIMENT INSTRUCTIONS, APPENDIX C

TEXT/PICTURE TRAINING - EXPERIMENT INSTRUCTIONS). These documents included links to both the Android and iPhone Outsmart application, links to create an EDDMapS account, instructions on using the apps, and contact information for the research team.

The participants were asked to keep their reports to three easy to identify invasives, Japanese knotweed (Fallopia japonica), autumn olive (Eleagnus umbellata), and multiflora rose (Rosa multiflora) and two more difficult species, glossy buckthorn

(Alnus frangula) and exotic honeysuckles (Lonicera spp). Hoping to mimic the actual Outsmart experience, the students were encouraged to do their reports anywhere within Massachusetts while undertaking whatever activities they so desired.

2. Recruiting Students for Participant Observation

To understand how people experience the Outsmart application, I needed to directly engage with individuals to elicit their contextualized understanding. This suggested using open-ended participant observation as a primary tool of inquiry. Participant observation would allow me to investigate how visual media shapes people's experience of Outsmart either through direct links made by the subjects themselves or through post-hoc analysis of participant observation transcripts and photographs. This approach could have been strengthened by taking a fully ethnographic approach to interacting with Outsmart participants, but this was made difficult by the ad hoc and distributed nature of Outsmart users. They use the application across New England, whenever they think to do so – it is nearly impossible to encounter Outsmart users "in the wild". The experiment posed a unique opportunity wherein I knew that there would be people using the application in a local context around the University of Massachusetts within a scoped timeframe.

After receiving Institutional Review Board approval for my work, I thus contacted one Natural Resources class participating in the experiment by email with permission of the instructor (see APPENDIX D

PARTICIPANT OBSERVATION RECRUITMENT E), offering no compensation and asking if I could follow along as an observer. I tried to be transparent about the motivation for my work, as well as offering any opportunities for collaboration or participation to the students.

In total, six students volunteered for the participant observation sessions, all of which took place during late September 2013. Four students volunteered individually over email. One of these four asked if they could bring along two other classmates to their session. While I had not initially planned for group sessions, I had no reason to deny this request. In fact, this likely mimicked how people would use the Outsmart app in reality, since hiking and exploring nature is often a social activity. I worked with each of them to schedule a mutually agreeable time. Participants were allowed to dictate both the location and the duration of our sessions.

Prior to our sessions, I emailed each of them the consent form, which included provisions about both recording and publishing audio/photography (see APPENDIX E

PARTICIPANT OBSERVATION CONSENT F). At the beginning of our sessions, I also spoke to each participant about the implications of the consent form, my planned use of photography as a research method, and asked them if they had any questions before I obtained their signature. I was very concerned about respecting their boundaries and being responsible as a researcher, especially since this was my first time focusing heavily on photography as a communication tool in my own work. Banks cautions, "All social researchers agree that unless there is a strong justification for doing otherwise, the social researcher has the duty to protect the privacy of research subjects…Generally, this is not possible when doing visual research (Banks 2008)." Given this duty, I asked all the participants if they wanted to review photographs after our sessions (which they declined), and if they were comfortable with me using their images publicly (they were).

B. Participant Observation Fieldwork

1. Letting the Participants Lead

While I had a list of possible discussion topics and questions to ask during the sessions, I tried to take an interpretive approach and let the participants shape the conversations as much as possible. The strength of this method lies in using the insider perspectives of each Outsmart user to illuminate their individual meaning of expert knowledge (Bayard de Volo & Schatz, 2004). An open-ended participant session allowed subjects to frame understanding in their language, not mine or the “expert” scientist language of a plant identification guru.

I was also able to identify additional important questions and conversations as these sessions progressed. I do recognize that this was directly related to my skill and identity as a researcher, as well as my own knowledge of plant identification, technology, and the Outsmart project. My conceptual understanding framed the questions I asked, the conversations I pursued, and the subsequent analysis I conducted (Yanow 2006). I also aimed to make sure the participants felt comfortable undertaking the task of participating in the Outsmart experiment, and that they were able to engage with me. The questions I asked were meant to contextualize the participant, their interests, and their expertise, as well as explore their use of the Outsmart application.

I met each participant at the location they requested, which occasionally required email or text-message communication for clarification since we were meeting outdoors to examine plants in areas that were on the border of the University of Massachusetts –

Amherst campus. I recorded and photographed all sessions, and took field notes to document my impressions.

2. Photography as a Data Collection Tool

Because of my focus on experience and visual media, I decided to make extensive use of photography in my own documentation of these sessions. Anthropologists have recognized that photography and video have the advantage of recording participants unobtrusively and systematically (Mead & Bateson, 2003). I viewed photography as more than just supplementary, however, and planned to use the photographs I took as a central piece of my analysis. I tried to take pictures illustrating different types of behavior and use of the app. I also wanted to capture moments of the participants using and experiencing the visual materials to identify plants. I did not stage any photographs, except for those in which I asked the participants to show me a plant, as I would have without the camera present. I tried as much as possible to capture their “natural” behavior, realizing that my presence and certainly the camera were altering how they acted.

Since I was both verbally engaging with the participants and taking photographs while they were using the Outsmart application, I had to balance competing goals. In probing for follow-ups and deciding when to take pictures, I focused on observing how people did things, rather than just directly listening to what they said. I focused on body language, such as eye focus, plant browsing behavior, and physical proximity to plants and other physical objects. I also paid attention to how the participants interacted with items eliciting comparison, such as their phone and the plants they were identifying. I also listened closely for any confusion or questions, since these could be indications of gaps in expertise or issues with the app design. Finally, I was particularly interested in the moments when the participants would decide to take pictures of the plants and submit reports, since this was a crucial moment with the potential to empower or confuse them. They would go from passive users to scientists themselves.

Interestingly, one of the sessions in which I took a larger number of photographs was one of the shorter ones. It was, however, the group session, and I was running back and forth between the three participants who dispersed geographically over our 42 minutes together, so I suspect that I used my camera to try to capture as many moments as I could, since I felt I was not able to engage with them each individually. In some ways, my camera became my second brain for that session, since I felt more frantic and used it to record things I might have otherwise forgotten or missed.

After each session, I uploaded all photographs and audio recordings to my computer and immediately assigned them an anonymous ID. I transcribed the audio files significantly later, in 2015, into text documents.

C. Application Feedback from NRC 297E

I also received an unexpected source of secondary textual data. Professor Paul Catanzaro, whose NRC 297E class was participating in the Outsmart experiment, administered a completely anonymous survey to all his students about their experiences. He designed this survey, which had four questions:

- Please list which group you were assigned to (e.g., in-person training, videos, app only).
- Please list what you liked about the Outsmart Invasives App.
- Please list what could be improved on the Outsmart Invasives App.

- Please list any other comments or suggestions. Feel free to use the back of the page.

Professor Catanzaro gave the completed forms to the Outsmart team, and before reviewing the content, I realized these surveys could be source of data for my research and could help me develop a richer understanding, a practice not unusual in qualitative research (Mason 2005). In particular, I was interested in whether or not participants identified visual media as salient features (as either pros or cons) during their experiences. 32 students completed the surveys, and I transcribed them verbatim into a table in Microsoft Word.

D. Interpretivist Foundations for this Research

A central piece of this thesis was to explore a person's experience of citizen science research activities using the Outsmart app. Because people's experiences are highly contextual and unpredictable, I did not limit my investigation to a pre-generated list of variables or explanatory theory. A rigid adherence to any framework would violate the epistemological recognition that context is fundamental in capturing individual knowledge. This methodology is consistent with interpretivist approaches. Interpretivism recognizes that all human experience is based on individualized, historically contingent perceptions comprised of the sum of our different experiences and meaning (Hawkesworth 2006). In particular, I was interested in the emotional and contextual experiences of citizen scientists, which made a deep, thorough examination of qualitative data appropriate to this study. Rather than drawing broad generalizations about large populations, I wanted to understand how each participant was individually shaped by his or her interactions with Outsmart and our time exploring plant identification together.

Instead, interpretivist methods require flexibility and in-the-moment response (Yanow & Schwartz-Shea, 2006). Through deep immersion in my data, I pursued any emergent trajectory that helped me generate explanations or hypotheses (Yanow 2006). Brady, Collier, and Seawright (Brady, Collier, & Seawright, 2010) acknowledge that this type of deep immersion and knowledge of context might allow researchers to identify factors that would not be considered in more traditional scientific research. While some scholars might be concerned that this flexibility might lead to research that lacks rigor and is of limited utility to other researchers, I ameliorated this risk through thoroughly documented, transparent processes.

Additionally, the concept of reflexivity is crucial to intrepretivist research, and so my analyses also include my own perspectives about my experiences with my participants: their interactions with me have a direct effect on the outcome of this work. By communicating the effects that my own identity, gender, race, class, education, and so forth have on this work, I hope to give the readers of this paper a better understanding of the context and position from which this research emerges (Banks 2008).

E. Qualitative Coding of Data

Table 1: Data Source Summary

Transcripts	Photographs	Field Notes	Audio Files	Secondary Text
4	152	5	4	1

The above table gives a summary of the data sources that I compiled from my research as described above. I imported all of these sources into Atlas.ti, a qualitative data analysis and research tool. I then began the iterative process of qualitatively coding my data, which is the process which links data collection to meaning (Charmaz 2001). Coding is interpretive and adds value to a research story by distilling, summarizing, and condensing data – it's the beginning of a process that allows you to group ideas into patterns (Saldaña 2012). Saldaña advises researchers to code "anything and everything that was collected" including all the documents related to participant activities and my own reflective documents. I used Atlas.ti to assign, organize, and categorize qualitative codes, as well as extract supporting quotes and visual evidence for the resulting narrative.

I used a coding process recommended by Saldaña in his very helpful book on qualitative coding. He provides choices of coding methods at each step, and I chose those that would be most appropriate to my subject matter and data sources:

1. Attribute coding: Basic descriptive information such as fieldwork setting, participant characteristics, data format, time frame; metadata.
    a. In my study, I coded all pieces of data with:
        i. Participant ID
        ii. Participant Plant ID Skill level
        iii. Which of the 5 plants the Participant can positively ID, if any
        iv. Experiment group (Image/Text, Video, or In person)
        v. Data type (Field Notes, Photograph, Transcript, Audio or Secondary Text),
        vi. Date
        vii. Location
        viii. Location Type (Grassland, Forest, or Urban Border)

2. Holistic coding: particularly appropriate for analyzing mixed data forms such as media and interview transcripts with bounded parameters of time and place; about grasping the theme of a piece of data as a whole, interpretive. Completed for all data, one code per datum.
3. Descriptive coding: summarizes data using a word or a short phrase, usually a noun. Completed for all data. One per photograph or audio file, many for text files.
4. In Vivo Coding: Provides voice and agency to participants; terms "that participants use in their everyday lives rather than in terms derived from the academic disciplines or professional practice" (Stringer 1999). Completed only for transcripts. Many per file.
5. Emotion coding: labels the emotions experienced by the participant. Completed only for photographs. One per photograph.

I finished each coding step for a session before I began the next step of coding. I also coded data from each participant (or group) in its entirety before moving onto the next, so that each session was as internally consistent as possible. Each type of code (Attribute, Holistic, Descriptive, In Vivo, or Emotion) was color coded so I could easily see at a glance what type of code a specific tag was and where I was in the analysis process for a piece of datum at any point in time.

Unlike textual analysis, where some automation can allow a computer to look for quantitative measures such as word frequency and perform complex searches, image coding is entirely interpretive (Banks 2008). Computer vision is not quite advanced enough to recognize conceptual differences between objects such as "house" versus “box”, at least at the consumer level quite yet. Photographs were central to my data collection and required some extra thought on how to code them with care. Scholars certainly vary in their perspectives on how to tackle coding images. Banks takes two perspectives: one, you can code the “internal narrative”, which is the content of the images and what you can see; or you can code the “external narratives” what you can’t, such as the stories and context in which the image takes place (2008). Saldaña actually does not recommend coding photographs directly as data, but instead coding the researcher’s “careful scrutiny of and reflection on images” using “rich, dynamic words” (2012). I decided to use Caldarola’s interpretation of pictures as event-specific representations (not generalized), which are context-dependent, social events, involving communication and mutual understanding, when I coded my images (Caldarola 1985).

Lichtman recommends that researchers use 80 to 100 codes that fall in approximately 15-20 categories that later get distilled into 5-7 major themes (Lichtman 2010). While I did not maintain categories or a count as I was coding my data, I did end up aiming to reduce my codes into a small number of major themes using code mapping after the first round of coding was complete. The in vivo coding meant I had significantly more than 100 codes after my first round (1434, to be exact). I used Atlas.ti’s Code Manager to code map my first round into meaningful categories, eliminating codes that did not seem to be as important to my analysis. Code mapping (grouping codes) into categories over a number of iterations helps a researcher “to bring meaning, structure, and order, to the data” (Anfara 2008). I did two rounds of code mapping; first creating 15 categories; then narrowing my analysis to four emergent themes using post-it notes. While some of categories I eliminated or condensed included incredibly interesting data, it was outside of the scope of this work (e.g., usability feedback or motivation for participation in citizen science studies).

CHAPTER V
EMERGENT THEMES

Plant identification is a difficult task requiring significant expertise, so I was able to investigate how visual media within the Outsmart app did or did not help the students participate in an activity that was often outside of their comfort zone. The app uses text descriptions for plants, with advanced language and jargon, so I was able to compare the utility of visual media to that of scientific language. Additionally, because Outsmart requires citizen scientists to submit photographs of the invasive species when making a report, I also was able to interrogate how the act of creating an image could be empowering for users. Would it feel engaging to see a photograph you've taken of an invasive you're reporting that is very similar to an image that appears in the app (an image created by experts)? Is the active participation in research something that feels natural or is the process too convoluted to be empowering? The table below summarizes the four separate participant observation sessions used in this case study. From these sessions, I was able to generate four emergent themes about how visual media is used by non-expert Outsmart participants in relation to language, creation of photographs, and participation if a citizen science project.

Table 2: Participant Observation Results Summary

ID	**Date**	**Session Length**	**Pictures**	**Skill Level**	**Gender**
01	9/23/13	41 min	21	Beginner	Woman
02	9/24/13	1 hr, 18 min	45	No experience	Men
03	9/24/13	42 min	40	Beginner, No	Woman, Man,

(group)				experience, Beginner	Woman
04	9/25/13	1 hr, 3 min	46	Intermediate	Man

A. The Self-Doubt of the Citizen

Table 3: Self-Doubt of the Citizen Theme Grouping – Top 5 Codes

Code	**Code Frequency**
Confidence	42
Expertise	42
Focused	25
Confusion	18
Learned expertise	17

While all the participants I interacted with were students enrolled in a plant identification class, none would be considered experts. Two self-identified as having no plant ID experience, three as beginners, and one as intermediate. They were all students, early on in their careers, with limited exposure to botany and environmental science. They were still learning many of the words and meanings relevant to plant identification; some of which is jargon that I was only vaguely familiar with; other words were entirely foreign to me. Botany is absolutely a field filled with language meant for experts and geeks: the average layperson does not know the difference between a pinnately lobed leaf and a palmately lobed one.

My participants were starting to grasp some of the language of experts, but these terms were often on the edge of their memories or easily confused ("The one I always have trouble with"). And more importantly, while they might have been able to recognize the terms "simple leaf" or "compound", they were not always able to apply them in the field yet without referring to the Outsmart app, which was fine! Because they were beginners! I found myself mining the recesses of my brain trying to remember plant anatomy as well, but there are so many different terms. What is the difference between compound and alternate leaves? I could not tell you off the top of my head, even if I might have known at one point in time.

Because plant identification is so difficult for a beginner, it became clear that self-doubt and confidence were serious issues for some of the participants. They used language such as "I don't know" and "Maybe" frequently, expressing self-doubt even after they had successfully identified a plant by comparing the pictures in the app to the physical features in the world. Two participants explicitly mentioned that they did not want to submit an incorrect report, despite knowing there was a human checking their work on the other end who would help them learn. I even mentioned that I knew the Subject Expert as a fellow graduate student and mentioned his name, in the hopes that humanizing the process might make it less intimidating. One seemed to not want to bother the SE with incorrect data, perhaps subconsciously reiterating earlier beliefs about proving himself. The other participant mentioned that she is a bit of a perfectionist and wanted to get things right.

Two of the men were also concerned about appearances as well, one of who had no experience. He said he would probably go out to identify plants by himself because "it's less pressure almost, like to perform, like here I don't really know what I'm talking about but I have to bring a friend along and have to prove myself". The other, intermediately skilled participant, expressed embarrassment when he could not remember the name of a particular species and had to rely on the app: “Was, uh, now I’m forgetting. Wait I’ll use the app to find out. Well c’mon!”

Table 4: Emotion Coding Summary (Codes appearing more than 5 times)

Emotion	**Code Frequency**
Focused	25
Curious	18
Engaged	13
Confident	11
Critical	11
Intrigued	9
Determined	7
Confused	6
Satisfied	5
Uncertain	5
Self-judging	5

I coded a number of photographs with emotional keywords expressing self-doubt including “confused”, “uncertain”, and “overwhelmed”. My most frequently used emotional code, “focused” (See Table 3), could indicate a participant’s resistance toward getting something wrong or not knowing what to do by being attentive to finding answers within the app or memory. In Figure **3:** Focused participant experiencing self-doubt about plant identification skills, the participant tried to remember all the plants within the experiment and their features, but was having trouble – a task that is cognitively difficult, even for an expert. It is unsurprising that the students experience self-doubt while identifying plants, especially as beginners, since it is a task that is requires significant expertise.

Figure 3: Focused participant experiencing self-doubt about plant identification skills

B. Salient Plant Features Don't Need to be Described with Expert Language

Table 5: Salient Plant Features Grouping – Top 5 Codes

Code	**Code Frequency**
Important plant features	73
Plants	17
Seasonality	13

Flowers	10
Smooth	7

After the first round of code mapping, I created a category called "Salient Plant Features" because many of the in vivo quotes I selected from my participants revolved around their use of words to refer to specific parts of each plant as they were touching them, attempting to find them in the app, or comparing them to photographs. Since the role of expert language was so critical in this study, I wanted to understand the actual terms my non-expert participants were using in practice. Were they familiar with plant anatomy language and using it colloquially? What words were most common, most useful to identification, most familiar?

I used Tagul.com to visualize all codes grouped within the "Salient Plant Features" category (171 codes) to produce a word cloud (Figure **4:** Word cloud for "Salient Plant Features" category; common words are excluded). Words that appear more frequently are displayed in the word cloud in a larger font. Based on this visualization, participants keyed in on three key features: leaves, flowers, and berries. In some ways, this is not surprising; these are some of the most visually salient features of plants that can be referred to in an image, text, and seen in real-life.

Figure 4: Word cloud for "Salient Plant Features" category

The less experienced participants, in particular, seemed to rely on the flowers and berries as a primary identification feature, possibly because of their lack of comfort with technical plant language. Even though the following participant knew complex plant anatomy terms (pinnate, palmate, simple), she was unsure of them and expressed some preference for flowering as an identification feature.

> "This…looks like the Glossy Buckthorn, well, since it is late in the season it's not flowering or anything…Really just have to focus on the leaves and stuff. And it's also in plant ID we learn whether they're compound or simple and um, pinnate or

palmate leaves, so trying to refresh my mind on that…but this actually, it's so hard."

Another participant admitted, "Yeah it's difficult, there's not much to go off when they don't have their flowers or berries". In contrast, one of the more experienced participants, who was able to identify a number of plants not within the scope of the experiment, said the first thing he looked at was "leaf characteristics", and he seemed comfortable with all the language used within the app.

The other words the participants used or referred to most frequently are terms describing color, shape, or texture. More importantly, the participants actually looked at the photographs and videos within the app and identified the salient visual features they deemed important and compared those to the plant they were attempting to identify in the real world. This is how one participant described why looking at pictures of the plant in the Outsmart convinced him his identification was correct: "Um, the close up of the stem, showing the kind of, the, the colors and the dots on the stem. The leaf, when they showed you the uh, upper side of the leaf, how it was green, and then when they showed you the image of the back it was silver." This was the most advanced participant, who had very little difficulty identifying any of the plants we looked at, and self-identified as someone with "intermediate" ID skills. Note how he spoke very conversationally about the colors and patterns of the plants and the very basic parts, with zero jargon or technical language.

C. The Power of Images to Inspire Comparison, Curiosity, and Collaboration

By using photographs to capture moments in the field, I was able to document how incredibly tactile using Outsmart was for all my participants, an experience that I coded as driven by "curiosity". I feel this must have been strange in some ways, in this technology driven world, to be so up close to something so natural; but that is what the images in the Outsmart app required – they "ask" people to examine nature a little more closely. I feel like I would not have been able to capture this relationship so profoundly had I not been taking pictures. The students were so close to nature: touching shrubs, feeling the glossiness of the leaves (Figure **5:** Glossy leaves are a salient feature), the roughness of stems (Figure **6:** Bark helps participant identify a plant), breaking off plants (Figure **7:** Is this hollow?) to see if they were hollow. During holistic coding, I called the images in Outsmart, a "Human Nature Interface".

Figure 5: Glossy leaves are a salient feature


Figure 6: Bark helps participant identify a plant


Figure 7: Is this hollow?

The images required tactile relationship because the images in the app invited direct comparison between plants in nature and images in the app. Even if a participant knew the correct terms for a plant's anatomy and could verify that those matched a text description, the final check would always be with the photographs of the plant in the Outsmart app. I also coded at least twenty in vivo quotes that were variations on "it looks like that" or "it doesn't look like that" right after participants directly compared a plant to an image in the Outsmart app. One of the most vivid illustrations of this can be seen in Figure **8:** Positioning the leaf for easy comparison:

Figure 8: Positioning the leaf for easy comparison

You can see the participant has broken off a leaf to directly position next to the phone in the exact orientation as the picture in the Outsmart app, so as to provide the most convincing identification comparison.

Videos and images within Outsmart also served as points of collaboration. Viewing myself as an ethnographic researcher, I actively participated in identification along with the students, so I helped them find plants and identify them whenever the opportunity presented itself. I did not want to push or provide any undue expertise, but given that all the students actually had more knowledge than I did, I did not feel like I was biasing the Outsmart experiment in any way. One participant said he actually appreciated having a second set of eyes, saying it was more fun to have someone else along to point out plants he might have missed. Participants would show their phones to me to ask me for my opinion, asking if a plant's leaf looked like the same color as a photograph in the app, for example. Or, if a participant was able to watch the videos based on their experiment treatment, we'd watch the videos together, hovering over the small screen, with the volume up to counteract the wind, hands shielding the small LCD against the bright midday sunlight.

I got to know the images and videos for the five target species because of what my participants shared with me, but I did not have knowledge of these species before this research – everything I know now came from what they shared with me in the few hours I spent with them. On the whole, what my participants showed me on their phones were visual media – images and videos. They might have read some quick descriptions out loud as they tried to understand a plant's features, but when they were asking my opinion or comparing notes, it was an image.

Images within the app could be limiting, however, if information was missing from the visual cues. Seasonality came up as theme, both from my participants and as feedback from the NRC297E class (10 out of 32 forms mentioned the lack of seasonal photographs). Many images supplied by the videos and within the plant descriptions are taken from the spring and summer, when plants are at their most ostentatious and easy to identify. This made it difficult for users to compare the plants they were identifying in the fall; plants that were flowerless, dying, and somewhat grim, to those in the app. As a result, you would have to be more expert to identify plants in the fall, and certainly in the winter.

D. Creating Media as Citizen Scientists as an Act of Empowerment

The act of submitting a photograph to report an invasive seemed to be an act of empowerment for participants – there was a clear positive emotional response when each person was able to correctly identify a plant and submit a report: “Wow!” “Yay!” “Yeah, perfect.” As a result, the act of taking a photograph to submit to Outsmart seemed very important to all the participants and was something they all focused time and energy on perfecting. The series of six photos in Figures 9-13 illustrate how many shots one participant took before finding one he was happy to submit.

Figure 9: Trying an angle from above

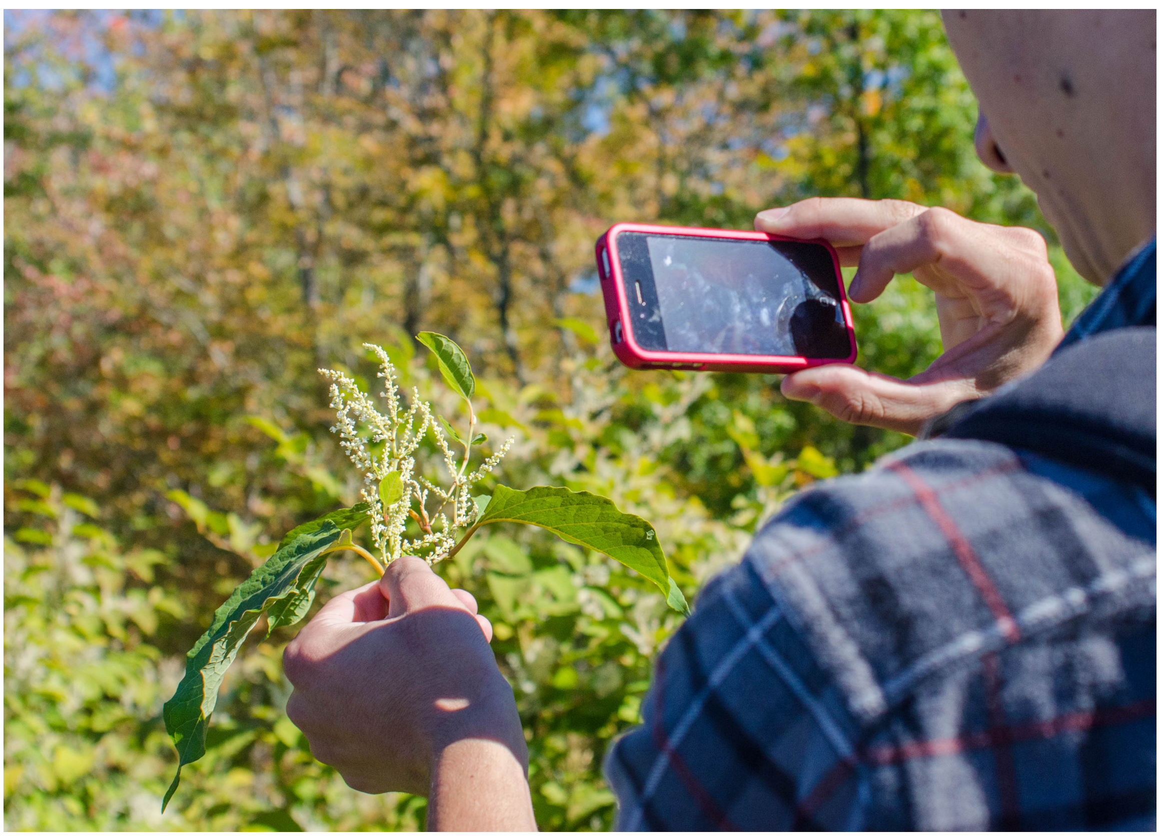

Figure 10: Better lighting

Figure 11: Repositioning

Figure 12: Getting a little distance

Figure 13: The winner

One participant expressed that he wanted to submit a photo that would be useful to the research team, so that they would be able to easily confirm his submission. Another looked at his photo for picture quality. In contrast, the group did tend to linger a little less, since they helped each other out with identification. They each would take their own pictures from their own angles, however, emphasizing the features that they seemed to think were most important. This seems to reinforce the finding that the act of creating a photo and contributing it to a citizen science project provides important agency and empowerment for each person.

CHAPTER VI
DISCUSSION

A. <u>Revisiting Research Questions</u>

1. Language vs. Visual Media

First, I would like to revisit the research question of "How do visual media, such as photographs and video, compare to language-focused resources (e.g. text, verbal) for citizen scientists?" From the results about language describing salient plant features, the participants tended to use terms that were not particularly technical or even limited to describing plants. This was often vivid, rich, visual language: "silvery", "hollow", "glossy", "toothed", words that were able to give even the novice an idea of what to look for when identifying a species. It was the images, with their colors, textures, and shapes that allowed the participants to make such detailed comparisons in the field.

The images and videos in the Outsmart app were able to help us make sense of the terms and jargon that botany uses to define plant anatomy. They did not just *tell* us that Glossy Buckthorn has alternate leaves, they *showed* us, in detail, in physical context, with all of its other important features as a plant. The participants, who started off having limited knowledge of these plants and their features, were able to submit reports by the end of all of my sessions. Even I, with no botany knowledge whatsoever, learned how to identify Glossy Buckthorn on sight. It was impressive how quickly that a plant once strange to this layperson became very familiar once I saw it contextualized in the images in Outsmart and then realized and applied in the real world.

Many of the images in Outsmart are close-ups or detailed shots of these species, so in some ways, the pictures invite an intimate relationship with these plants. It is interesting to think that Outsmart is establishing a relationship that is close-up and friendly to identify a species, but is also predicated on the notion the same plant is a dangerous invader. This close relationship seemed to provide confidence, which was an emotion that I coded in 11 photographs (typically in scenes of participants looking at images). Sometimes, however, the participants did not trust their own knowledge and expertise (see earlier discussion), so if the plant they were looking at matched an actual photograph in the app, I believe that made the identification more "real" in their minds. Photographs are often given as concrete evidence, whereas language and description are perceived as more subjective.

The participants also shared images with me frequently. Is this because images are easier to share on a phone? Are images just more prominent on the Outsmart app? I believe it is because the images were a shared language between us – we both could look at the speckled, taupe bark in a picture and see if it matched a shrub we were examining. Images seem universal, especially within non-specialized communities of practice.

2. Empowerment through creation of visual media

Now, I will revisit my second research question, "does the act of creating visual media and contributing it to a project feel empowering to a citizen scientist?" As I discussed earlier, the act of taking a photograph was incredibly important to my participants. After spending so much time and effort identifying plant, they wanted to "get it right". They seemed to be trying to recreate the same images that they saw in the app. This act of creation was about capturing the important plant features such as leaf shape, berry color, and texture that helped them understand what they were seeing. In particular, the students wanted the knowledge they obtained to be shared with the researchers on the Outsmart team, so it was crucial that the photograph was valid, clear, and accurate. I believe they saw themselves as active members of the scientific process – the photographic submissions was the part of the process that changed them from passive browsers to empowered scientists.

However, even with the explicit resource of the Outsmart app at their disposal, the participants' feelings of vulnerability and self-esteem seemed potentially tied to their ability to be experts without help and without guidance. I worry that novices often have higher expectations of themselves because they do not realistically know what they should and should not be able to do; their limits are boundless. Whereas experts have the wisdom to realize they cannot and should not know everything: they are unafraid to seek guidance when they need it.

B. Implications

While I consider this study contextual to the Outsmart project and my experiences with my participants, I believe we can gain some more general insights about the use of visual media to help non-expert participants have empowering experiences in citizen science projects. I suspect many novices in many fields will suffer from self-doubt and confidence issues, as my participants did, so citizen science project designers should be aware of this fact and be as empathetic as possible when designing their programs to account for this entirely natural emotional reaction. Make it so participants do not have to "prove" themselves to be involved. Don't subject them to public examinations or demonstrations that will require them to test their knowledge in front of others – this means either in person or virtually. Consider a design that might support anonymous submissions. In other words, be thoughtful about how you might contribute, positively or negatively, to your participants' self esteem.

In dealing with citizens, researchers should strongly consider more using images as a way to engage the public. Jargon and technical language can be alienating and overwhelming, whereas visual tools have the potential to be more easily understood by wider audiences and created shared meaning between researchers and the public. Additionally, citizen science projects should look into participatory visual research methods as possible inspiration for ways to incorporate the public more actively into the design process of the actual programs themselves. I believe Outsmart's process of asking participants to submit photographs just scratches the surface of empowering citizens through participatory media creation.

C. Future Work

In future work, I would be interested to see how experts and professionals use visual media to aid them in field identification or other cognitively difficult tasks. Clearly, academics communicate primarily through the written word with each other in formal contexts, but I would be intrigued to discover how diagrams, photographs, and other media are used as memory aids when technical language and jargon is less burdensome.

There also has been very little theoretical work completed on how visual media can be used to bridge the gap between experts and non-experts in technical fields. While this thesis has started to explore some of these issues as a case study, future work should develop the theoretical foundations by drawing upon literature from information science, anthropology, and other social science disciplines.

APPENDIX A

IN-PERSON TRAINING - EXPERIMENT INSTRUCTIONS

Thank you for signing up to participate in the Outsmart 2013 study! For more information on the research implications of this study and why your participation is important, visit www.masswoods.net/outsmart

IMPORTANT: Please read the instructions below in their entirety, which outline the steps you need to take to participate in the study.

You have indicated you have been trained in plant identification by an Outsmart team member. If this is not the case, please contact the outsmart team (outsmartinvasivespecies@gmail.com).

If you have not already done so, please:

- Download the Outsmart app on your smartphone from either the Google Play store or iTunes AND
- Create an EDDMapS account at: http://www.eddmaps.org/outsmart/join.cfm.

Until September 30, 2013, please use the Outsmart app to submit as **many sightings as you can of the following five plants**:

- Japanese knotweed
- Glossy buckthorn
- Autumn olive
- Honeysuckle
- Multiflora rose

To identify these species, please use BOTH the pictures AND videos within the Outsmart application. Pictures and videos can both be found under the individual species within the app. Please feel free to submit any sightings of other species.

If you have any questions at all, do not hesitate to contact our project team at outsmartinvasivespecies@gmail.com.

Thank you for your help in combating invasive species!

APPENDIX B

VIDEO TRAINING - EXPERIMENT INSTRUCTIONS

Thank you for signing up to participate in the Outsmart 2013 study! For more information on the research implications of this study and why your participation is important, visit www.masswoods.net/outsmart

IMPORTANT: Please read the instructions below in their entirety, which outline the steps you need to take to participate in the study.

If you have not already done so, please:

- Download the Outsmart app on your smartphone from either the Google Play store or iTunes AND
- Create an EDDMapS account at: http://www.eddmaps.org/outsmart/join.cfm.

Until September 30, 2013, please use the Outsmart app to submit as **many sightings as you can of the following five plants**:

- Japanese knotweed
- Glossy buckthorn
- Autumn olive
- Honeysuckle
- Multiflora rose

To identify these species, please use BOTH the pictures AND videos within the Outsmart application. Pictures and videos can both be found under the individual species within the app. Please feel free to submit any sightings of other species.

If you have any questions at all, do not hesitate to contact our project team at outsmartinvasivespecies@gmail.com.

Thank you for your help in combating invasive species!

APPENDIX C

TEXT/PICTURE TRAINING - EXPERIMENT INSTRUCTIONS

Thank you for signing up to participate in the Outsmart 2013 study! For more information on the research implications of this study and why your participation is important, visit www.masswoods.net/outsmart

IMPORTANT: Please read the instructions below in their entirety, which outline the steps you need to take to participate in the study.

If you have not already done so, please:

- Download the Outsmart app on your smartphone from either the Google Play store or iTunes AND
- Create an EDDMapS account at: http://www.eddmaps.org/outsmart/join.cfm.

Until September 30, 2013, please use the Outsmart app to submit as **many sightings as you can of the following five plants**:

- Japanese knotweed
- Glossy buckthorn
- Autumn olive
- Honeysuckle
- Multiflora rose

To identify these species, use ONLY the pictures and text within the Outsmart application. Do not use ANY of the videos within the Outsmart application or view Outsmart videos online. Please feel free to submit any sightings of other species.

If you have any questions at all, do not hesitate to contact our project team at outsmartinvasivespecies@gmail.com.

Thank you for your help in combating invasive species!

APPENDIX D

PARTICIPANT OBSERVATION RECRUITMENT EMAIL

My name is Megan Kierstead, and I'm a graduate student in Environmental Conservation who really needs your help! My work is about understanding how people use technology and using that knowledge to design better solutions. One important piece of this research is seeing how people actually do something in a "natural" setting, which is where you come into the picture. I'm hoping you'll help me improve Outsmart!

I'm looking to "shadow" a small number of students using Outsmart out in the world. This doesn't require extra effort on your part beyond sending me an email – you just have to be willing to let me tag along when you're outside using the app. I'll ask you some questions, take some photographs, and let you do your thing. I will be trying to make this as easy and interesting as possible. Participating will not affect your coursework either positively or negatively.

Since I view anyone participating in my research as a collaborator, you'll be given access to any media from our session, to use or modify as you see fit. If you end up deciding you don't want me to use any material after you review it, you can let me know, and I won't include it, no questions asked. Alternatively, if you decide the work I'm doing is super interesting and want to be more involved, I'm open to any and all forms of collaboration (papers, posters, exhibits, etc.).

If you have any questions or concerns about participating, please don't hesitate to email me at megan.kierstead@gmail.com. I'm also happy to talk about my work, and how this fits into the big picture of Outsmart and technology research.

Thank you!

APPENDIX E

PARTICIPANT OBSERVATION CONSENT FORM

Consent Form for Participation in a Research Study
University of Massachusetts Amherst

Principal Investigators: Megan Kierstead and Charles Schweik
Study Title: Outsmart Invasive Species

1. What is this form?
This form is called a Consent Form. It will give you information about the study so you can make an informed decision about participation in this research study.

2. WHO IS ELIGIBLE TO PARTICIPATE?
Anyone over 18 years of age is eligible to participate.

3. WHAT IS THE PURPOSE OF THIS STUDY?
The purpose of the research is to study how people use and experience the Outsmart Invasive Species mobile application. Through observing and talking to people using the application in a real-world setting, we hope to better understand the challenges and opportunities a mobile-based citizen science system might present.

4. WHERE WILL THE STUDY TAKE PLACE AND HOW LONG WILL IT LAST?
The study will take place in locations in Massachusetts. Observation sessions will be scheduled with participants, who will also determine the duration of the sessions, but will likely take no more than an hour or two.

5. WHAT WILL I BE ASKED TO DO?
If you decide to participate, then you will be observed and interviewed while using the Outsmart Invasive Species application. We would like to photograph and audiotape parts of this process. You will not be recorded, unless you give permission. If you give permission to be taped by signing this form, you have the right to ask for the recording to be stopped. You have the option to indicate whether you would like these recordings to be used for conference presentations, as well as education and training of future researchers/practitioners or archived for future research on this form. You also have the option of refusing to be photographed or requesting that photographs are anonym zed. We also might wish to follow-up with you with some additional questions about your experience after your session.
The researcher will ask you questions on topics such as these:

How did you decide to visit this location?
What do you find frustrating about the Outsmart application?

6. What are my benefits of being in this study?
Although there may be no direct benefits to you, the possible benefits of your participation in the research are helping to increase knowledge about citizen science and public engagement with technology and improving invasive species data collection. There are no foreseeable risks or discomforts to your participation. Participating will not positively or negatively affect your coursework.

7. WHAT ARE my RISKS OF being in THIS STUDY?
There are no known risks from taking part in this study, but in any research, there is some possibility that you may be subject to risks that have not yet been identified.

8. How will my personal information be protected?
Except for public figures who wish to speak "on the record," the researcher will not refer to participants by their real names in any presentation or written work, or in conversation or correspondence with anyone other than the participants themselves.

Audio recordings: Portions of audio recordings made during this study may be played for others. Audio recordings may be played for groups of the researcher's colleagues and students, and for participants in more public events, such as conferences. Confidentiality cannot be guaranteed due to situations where the researcher is legally required to report information. In addition, there is a chance your voice or likeness may be identified in audio recordings or photographs.
The data (field notes, transcripts, audio and photographs) will be kept in a secure place and will be archived and used by the researchers(s) for research and dissemination purposes only. Upon completion of the study, anonymized data may be donated to an academic research archive. Any archived data that contains identifying information about participants will be placed in a secure data enclave.
Written materials and presentations: The researcher may include descriptions of activities and interactions, as well as transcriptions of quotes from audio recordings, in this academic research and in public presentations and published articles based on his research. The researcher's findings may also be shared with non-profit organizations and government agencies.

As noted above, you will not be identified by name in any shared data, publications, or presentations, unless you ask to be. The confidentiality of study records and audio and photographs will be protected according to the following procedures. The researcher will keep all study records (including any codes to your data) in a secure location. Research records will be labeled with code numbers or pseudonyms. A master key that links real names and codes/pseudonyms will be maintained in a separate and secure location. All electronic files containing identifiable information will be password protected. Any computer hosting such files will also have password protection to prevent access by unauthorized users. Only the researcher will have access to the passwords.

Confidentiality cannot be guaranteed in situations where the researcher is legally required to report information (e.g., in cases of child abuse or neglect).

9. COMPENSATION
You will not receive any compensation for your participation in this project.

10. WHAT IF I HAVE QUESTIONS?
Take as long as you like before you make a decision. The researcher will be happy to answer any question you have about this study. If you have further questions about this project or if you have a research-related problem, you may contact Megan Kierstead, megan.kierstead@gmail.com or her advisor, Dr. Charles Schweik, cschweik@pubpol.umass.edu. If you have any questions concerning your rights as a research subject, you may contact the University of Massachusetts Amherst Human Research Protection Office (HRPO) at (413) 545-3428 or humansubjects@ora.umass.edu.

11. CAN I STOP BEING IN THE STUDY?
You do not have to be in this study if you do not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide that you do not want to participate.

12. WHAT IF I AM INJURED?
The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subjects research, but the study personnel will assist you in getting treatment.

13. SUBJECT STATEMENT OF VOLUNTARY CONSENT
I have read this form and decided that I will participate in the project described above. The general purposes and particulars of the study as well as possible hazards and inconveniences have been explained to my satisfaction. I understand that I can withdraw at any time.

______I agree that segments of the recordings made of my participation in this research may be used for conference presentations, as well as education and training of future researchers/practitioners.

______I do not agree to allow segments of recordings of my participation in this research to be used for conference presentations or education and training purposes.

______I agree to have my recordings archived for future research.

______I do not agree to have my recordings archived for future research.

______I agree that photographs of my participation in this research may be used for conference presentations, as well as education and training of future researchers/practitioners.

______I do not agree to allow photographs of my participation in this research to be used for conference presentations or education and training purposes.

______I agree to have my photographs archived for future research.

______I do not agree to have my photographs archived for future research.

____________________________	_______________________	___________
Participant Signature	Print Name	Date

By signing below I indicate that the participant has read and, to the best of my knowledge, understands the details contained in this document and has been given a copy.

_____________________________	Megan Kierstead	___________
Signature of Person Obtaining Consent	Print Name	Date

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