Engaging Citizen Analysts to Create a Canadian Public Policy Memex

Justin Longo
Cisco Research Chair in Big Data and Open Government
Johnson-Shoyama Graduate School of Public Policy
University of Regina
3737 Wascana Parkway
Regina, SK, Canada S4S 0A2
Phone: 306-585-4942
Justin.Longo@uregina.ca

ABSTRACT

There is a rich history of public management and public policy research and practice in Canada, dating back more than 50 years. For the company of practitioners and scholars that have led this country's government organizations and the academic fields of public policy and public administration, their contributions live on through official records and published writings. Yet, much of the valuable ephemera and background colour underlying the process of creating these records lies dormant, locked in the personal libraries, papers, file boxes and hard drives of these pioneers. Records like published works currently unavailable, publications by other authors containing the owner's marginal notes, draft versions of later publications, unpublished material never widely circulated, personal correspondence of historical importance, and notebooks that contain the genesis of later insights. Extracting value from these isolated archives involves a process of collection, digitization, machine recognition, and human interpretation. This paper describes a proposed project to digitize, archive, categorize, machine process, and crowd-prioritize, -evaluate, -interpret, and -analyze these records based on a virtual citizen science model. The proposal is illustrated with a proof-of-concept prototype. This project seeks to bring to light the currently hidden treasures from these leaders' personal libraries and private papers, and provide a platform for accumulating and enhancing these artefacts, transforming them into a common cultural resource and supplement for future scholarship and practice.

Keywords

Canada, government, public policy, history, citizen science, crowdsourcing, personal libraries, private papers.

1. INTRODUCTION

There is a long history of Canadian public policy research and practice, spanning the past half-century. Guided by a constellation of luminaries working across academia, civil society, business, and governments, these scholars and practitioners had an enormous influence on the field over its early years and were responsible for significant theoretical and applied advances in public policy in Canada. Many of these leaders have reached or are nearing the end of their careers, and while much of their work lives on in published literature and legislation, these formal works can only capture part of the full breadth of the knowledge and wisdom they amassed during their working lives. Fortunately, many of these same leaders are of an era where they have accumulated personal libraries and collections of private papers that contain materials that capture some of this knowledge and wisdom, and document the history of the policy analysis movement in Canada. These collections of papers, books, notes, and correspondence potentially contain some of the policy wisdom that the field's pioneers cultivated long ago.

Two central problems stand in the way of making these isolated collections available widely and useful, however. First is the task of finding and collecting them into a comprehensive, searchable, digital database. Second is the challenge of making sense of what is surely a large volume of data and information when such a task is beyond current machine technology and which is too costly to consider doing manually with paid archivists. The premise of this paper is that both challenges can be plausibly addressed using techniques variously referred to as crowdsourcing and citizen science. Because public policy analysis lies at the foundation of this proposed project, the term used here is "citizen analysis".

This paper presents a proposal and proof-of-concept for building a virtual online library of the individual personal libraries and private papers of the leaders in Canadian public policy over the past half-century, and coupling that archive with a citizen analyst approach to categorizing, prioritizing, evaluating, interpreting, and analysing the collected works.[1] I begin with a scan of the literature and prior examples to illustrate the value in the proposed project and its feasibility (including why volunteers would do the work). I then discuss several impediments to the proposal, including logistical and financial, but centring on copyright, freedom of information, and protection of privacy concerns. I then present the proof-of-concept with examples, followed by a model for building a virtual archive of personal libraries and private papers accumulated digitally through a number of regional centres. The paper concludes with a roadmap for undertaking this collaborative project and a call to action for partner organizations across Canada to join this collaborative endeavour.

CAPPA 2016, May 16-17, 2016, Quebec City, Quebec, Canada

[1] The term Memex is used in honour of the system described by Vannevar Bush in the 1945 Atlantic Monthly article "As We May Think", which described a device that would store all of a person's books, records, and communications with a system to aid in retrieval (see Bush 1945).

2. BACKGROUND

The personal libraries and private papers of authors, artists, scholars, and other accomplished individuals often are donated to and housed in the special collections areas of libraries. These collections centre on the books collected by the donor, though also often contain informal and periodic publications, correspondence, mementos, memorabilia, and other ephemera. Within the copies of publications by other writers, the owner may have added annotations ranging from occasional underlining to detailed marginal notes. For traditional libraries, these personal libraries and private papers often present unique cataloguing and processing challenges (Gribben 1986; Nicholson 2010). Yet for scholars and interested observers, the rich data in these personal collections that accompanies published literature is invaluable for understanding the person and the era in which they worked.

There is a rich history of public management and public policy research and practice in Canada, reaching back more than 50 years (Mintrom 2007). For the company of practitioners and scholars that have led this country's government organizations and academic fields, their contributions live on through legislation, official records, and published writings. Yet, much of the valuable ephemera and background colour underlying the process of creating these works lies dormant, locked away in the personal libraries and private papers of these pioneers. Records like published works currently unavailable, publications by other authors containing the owner's marginal notes, draft versions of later publications, personal correspondence of historical importance, and notes that contain the genesis of later developments. However, these personal libraries and collections of private papers of Canadian public management and public policy practitioners and scholars that have been at the centre of this history are inaccessible to most scholars and interested observers. Even if they were made available, for example in special collections archives in a library affiliated with the donor, they are often unreachable by many except the most dedicated scholar.[2] Even if reachable, any interpretation and analysis of the original documents often remains with the individual researcher until published.

This proposed project is premised on there being value in the flotsam and jetsam of the offices of these leaders in the Canadian public policy movement. The challenge, if this is true, is to determine how we can reasonably go about revealing these needles of wisdom in the haystacks of detritus? Even before undertaking such analysis, even collecting those haystacks is not a simple challenge. Two central problems stand in the way of making these now-isolated private collections publicly available, and to make their availability useful. First is finding and collecting them into a comprehensive, searchable, digital database. Second is making sense of the large volume of data and information that would be collected.

The challenge of accumulating the material for creating the archive can be addressed through an elite-focused effort that encourages public policy leaders and their estates to lend materials for digital capture, and through a bottom-up crowdsourcing approach that allows any donor to contribute material electronically through a web interface. As to the secondary challenge of analyzing this fire hose of date, previous examples illustrate that this can be plausibly addressed through the work of volunteer citizen analysts who would categorize, prioritize, evaluate, interpret, and analyze the accumulated material using an online platform.

The concept of "citizen analysts" is derived direction from prior work in citizen science. Citizen science initiatives allow volunteer participants to collect observations, interpret data, and contribute to formal scientific projects. A large and growing number of opportunities are available for volunteer enthusiasts to contribute to science through field studies, organized events, classroom-based activities, and open science investigations (Wiggins & Crowston 2011). The particular approach to citizen science adopted here is referred to as virtual citizen science (VCS), where volunteer participation is facilitated through websites and Internet-enabled mobile applications (Reed et al. 2012). VCS has grown since the mid-2000s using Web 2.0 technology and in response to increasing scientific data flows that have outstripped the capacity of professional scientists to analyze them (Kanefsky et al. 2001; Gray et al. 2005).

Previous citizen science projects and the literature also indicate that there is a range of reasons why people participate in VCS initiatives (Nov et al. 2011a, 2011b, 2014; Rotman et al. 2012; Reed et al. 2013; Jackson et al. 2015). Because of these diverse and complex motives, a number of systems have been instituted to encourage participation including virtual rewards systems, game-like environments, and social networking features (Bowser et al. 2013; Eveleigh et al. 2013; Iacovides et al. 2013). Despite these efforts, and because of the growing number of opportunities to engage in VCS projects, recent work on how to engage, retain, and usefully apply the volunteers efforts of VCS participants indicates that providing participants with reasons to continue contributing remains as a major challenge (Wald, Longo & Dobell 2016). Nonetheless, there is a long list of VCS projects that demonstrate that volunteer participants can be relied upon to undertake valuable work on behalf of online citizen science projects and to do so with accuracy.[3] Two leading examples – Clickworkers, and the Zooniverse – provide just a glimpse into this list.

ClickWorkers stands as the original version of the VCS model, created by NASA to solve a particular problem: the NASA Mars Viking Orbiter had completely photographed the surface of Mars, but these photographs needed to be annotated in order to be useful for future exploration. But rather than do what they normally did - which was to create a post-doctoral fellowship position with the mind-numbing task of identifying the craters and classifying the features of the landscape - NASA thought that maybe this rocket science wasn't rocket science after all and that circling craters on a meter-by-meter image was something that most people could do. So they put the images online, available to anyone with an Internet connection, and provided a simple annotation tool with instructions to draw circles around craters. For a task that was estimated would take two postdocs two years to complete, the response was astonishing. Within six months, 85 000 volunteers had reviewed all images and had made 1.9 million annotations. To guard against inaccuracies and even mischief, each image was annotated independently 20 times and their annotations were averaged. An analysis of the quality of markings showed "that the automatically-computed consensus of a large

[2] One example of an online repository of such records is the "Diefenbaker Library Collection" housed at the University of Saskatchewan containing the papers and books of Canada's 13th Prime Minister <http://library.usask.ca/archives/collections/diefenbaker-archival-collections.php>. (Diamond 1990)

[3] A recently compiled database of VCS projects is available at http://bit.ly/1BP3mtI

number of clickworkers is virtually indistinguishable from the inputs of a geologist with years of experience in identifying Mars craters."[4] The Clickworkers project was a particularly clear example of how what was seen as a professional task requiring the efforts of highly trained individuals on full-time salaries could be reorganized so as to be performed by tens of thousands of volunteers in increments so small and simple that the tasks could be completed more quickly and on a much lower budget. With this successful demonstration of a crowd-based science activity, the VCS model was born. Principles that emerged from the Clickworkers experiment led to a number of central principles for the deployment of similar science-oriented crowdsourcing initiatives:

1. Preliminary tasks should be **simple**, with easily understood instructions and ability for an untrained person to undertake productive work immediately.
2. **Visual** tasks that exploit human abilities in pattern recognition allow for productive use of volunteer effort.
3. An **intuitive**, interactive interface is important for engaging users and leading to repetitive interaction.
4. **Training** that improves the effectiveness of the respondent must be provided; a training period can also serves to assess the reliability of the respondent against already-categorized data.
5. Occasional random testing or **validation of responses** on a continuing basis will be needed.
6. Users should have the option or ability to move from introductory simple tasks to **higher-order tasks** that require additional judgment.
7. Data should come from **large volume databases** that reduce the probability of individuals receiving obviously redundant samples.

The Clickworkers example led to the creation of Galaxy Zoo[5] and later the wide-ranging Zooniverse[6] which started as a platform to have Internet-enabled volunteers look at images of galaxies and then classify them by their shape but now includes VCS opportunities spanning astronomy, marine and land-based ecology, cell biology, climate sciences, and the humanities. Jointly headquartered at Oxford University and the Adler Planetarium, the Zooniverse has grown since its launch in 2009 to a current count of 41 active projects with over 1 million registered participants. The Zooniverse deployed a freely available "build a project" feature that allows anyone to develop a VCS project on the Zooniverse platform (Bowyer 2015). The prototype demonstrated in this paper is built using this facility.

Virtual citizen science is also sometimes referred to as science-oriented crowdsourcing, a term used to describe the process of taking a task traditionally performed by an employee or otherwise engaged person and allocating it to a large and dispersed set of volunteers using the Internet as the medium for communicating the request for action, allocating the task, and collecting the results. This approach has emerged in recent years as a response to situations involving high-volume data sets requiring human interpretation and reasoning where it is cost-prohibitive to undertake that task within an organization, where the task is too large to be completed in a reasonable time-frame by the resources within the organization, and/or where the completion of the task would benefit from multiple perspectives beyond the scale of the organization.

Whether called VCS or science-oriented crowdsourcing, successful projects usually include tasks that:

- are comprised of a large number of discrete, simple human-based computations or applications of human pattern recognition,
- require very little time on the part of the volunteer to learn how to complete the task and actually complete one instance of the task, and
- give the volunteer some measure of reward, and a sense of accomplishment and of having contributed to a larger undertaking through a very simple, short interaction.

Extracting value from a VCS archive usually centres on a process of collection, digitization, machine recognition, and human interpretation. The VCS movement is largely built on the premise that computers should do what computers are good at - e.g., gathering, indexing, comparing - and people should do what people are good at - e.g., querying, deciding, thinking, and these human processing skills should be applied to those elements in a high-volume data stream that are not optimally amenable to machine computation, but are of such scale that it is resource-prohibitive to employ enough qualified people to do so. While the digital era lets us collect and keep large volumes of data, transforming data into useful information still requires analysis. Extracting knowledge from electronic databases remains a central challenge of knowledge management systems. Machine algorithms can do some of these tasks, and are continually getting better at them. But VCS projects continue to be developed because some tasks still require the unique capacities of people to interpret data. In the early years of the VCS model, most projects asked volunteers to interpret camera imagery, e.g., telescope photographs of galaxies. More recently, however, the model has spread to the humanities and social sciences, with volunteer analysis of documents of historical interest being a prominent type.[7] Even when optical character recognition (OCR) can be used to digitize printed text, the VCS approach is used especially where the text is unclear or when handwriting is present (Plamondon and Srihari 2000).

A good example of this is another NASA project that sought to add value to a collection of internal memos written in the 1960s and unearthed in 2008. Wernher von Braun, the first director of NASA's Marshall Space Flight Center (MSFC) used his "Weekly Notes" to communicate developments of importance to employees in the MSFC. As a key figure in the development of the Saturn V rocket and NASA's Apollo program, von Braun used these memos to track program and organizational issues at MSFC. Long forgotten as transitory records of little contemporary interest, the complete collection was found in the personal papers of a retired

[4] "Clickworkers results: crater marking activity," July 3, 2001; previously available at http://clickworkers.arc.nasa.gov (accessed April 25, 2005; quoted in Benkler and Nissenbaum 2006, p. 397).

[5] http://www.galaxyzoo.org/

[6] https://www.zooniverse.org/

[7] Two prominent examples on the Zooniverse platform are "Shakespeare's World", which asks participants to transcribe documents handwritten by William Shakespeare's contemporaries with the goal of understanding the playwright's life and times <https://www.shakespearesworld.org> and "AnnoTate", a transcription tool that lets volunteers read and transcribe the personal papers of British-born and émigré artists housed in the world's largest archive of British Art <https://anno.tate.org.uk>.

MSFC employee and is now considered to be a valuable source of historical data. While these records have been captured as digital images,[8] two central challenges are presented by the collection: the original text is not accurately deciphered by OCR software, and the records contain many marginal notes of interest – also not amenable to OCR interpretation. NASA issued a request for information in 2009 to "seek comments from the public, academia, and industry to address aspects or concepts on how NASA should proceed to analyze and catalog these notes into an electronic, searchable database or other medium" (NASA 2009, 1).

Of the ways that the science community interacts with the public, two reasons include outreach to adults in order to build and strengthen its constituency with a view to securing support for continued research funding, and through education for children to build enthusiasm for career choices that will build and renew the future ranks of the science community. VCS seeks to tap the cognitive surplus (Shirky 2010) of large numbers of dispersed volunteers to improve the value of the data to the scientific community and, subsequently, the quality of the evidence provided by the scientific community as a basis for public deliberation. Citizen science initiatives represent another type of science / public relationship that has existed ever since the emergence of a professional scientist class. The National Audubon Society's annual *Christmas Bird Count* has operated for over 110 years in North America as a volunteer-driven census of birds, providing population data for use in science. Amateurs have a long history of contributing to research in astronomy including the continuing discovery of comets and supernovae. In each case of such citizen science, contributions typically involve volunteers providing their own resources and equipment to undertake the observations (e.g., telescopes, binoculars, diving equipment, locating to field sites), their own time, and the powers of human perception, reasoning and pattern recognition that still outperform the most powerful machines.

VCS programs may be emphasizing the scientific objectives and benefits to science flowing from them while volunteers, especially as an initial reason to participate, are interested in the personal benefits they will receive from participating in a project. This difference may contribute to challenges in engaging participants interested in goals that are not being emphasized by the available VCS projects. Thus, incentives for recruitment should focus on tools that allow participants to fulfill personal needs (Rotman et al. 2012). A related benefit is that education materials and workshops that allow volunteers to learn more about the subject can also help reduce the perceived barriers that might discourage the public from engaging in participatory science projects (Raddick et al. 2010). Tools to manipulate data and compare results among volunteers have also been found to increase project participation (Bonney et al. 2009). Although volunteer recognition was important for long-term engagement in a project, it was not an important motivator for initial engagement in VCS projects (Rotman et al. 2012). Therefore, this may be an appropriate incentive to emphasize to returning participants, but may not necessarily contribute to the recruitment of new volunteers.

Virtual citizen science targets the productive use of free time that individuals have when not attending to work, mandatory education, chores, responsibilities, personal care, and sleeping. Shirky (2010) labels the reasoning capacity offered by this free time not used for passive consumption of entertainment like television (Putnam 1995), or in low-cognitive load activities like commuting, a "cognitive surplus" waiting to be tapped for productive purposes. That cognitive surplus can now be oriented towards the active and collaborative production and co-creation of content collected and disseminated through the medium of the Internet, including VCS initiatives. While cognitive surplus might be considered a virtually limitless resource (e.g., Shirky (2010) estimates Americans watch two hundred billion hours of television annually), concerns about declining engagement, attention, and total capacity in the open collaboration space are beginning to emerge (Halfaker et al. 2013). In such an environment, VCS projects must appeal to the perspective of potential participants to recruit, engage and retain volunteers. Volunteers may be motivated more by a search for diversion, entertainment, or personal educational goals, and may only come to be motivated by the specific goals of the project through the enrichment of their volunteer experience (Wald, Longo and Dobell 2016).

3. CHALLENGES

Can a virtual archive of the personal libraries and private papers of the leading architects and builders of the public policy movement in Canada active over the past half-century be collected? And if it were collected as an assembly of digital images of printed books, papers, and files, could a VCS approach relying on the volunteer efforts of citizen analysts serve to categorize, prioritize, evaluate, interpret, and analyze these records? While similar VCS projects indicate the plausibility of the proposed project, several potential impediments bear considering.

Some logistical challenges in collecting source materials and assembling them into a digital archive. Identifying candidate donors can be undertaken by regional partners based on local preferences, though criteria for inclusion could include past civil service leaders in federal, provincial, and territorial governments (e.g., Clerks of the Privy Council), leading public policy academics, and past leaders of civil society public policy organizations. Those individuals or their estates can then be contacted with a request to donate their personal library and private paper collections to be digitized by the regional partners.

Will they respond positively to such requests? While a condition of donation may be that the materials be returned in their original condition after they are scanned, there may be concerns about contents not intended for distribution, or loss of or damage to originals. The potential for embarrassment (to the documents owner or persons named in them) is real. How other than through a manually sifting through the entire collection can we determine if a record was not meant for public distribution? The regional partners cannot determine appropriateness; rather, the owner or their estate must do so. This task is not trivial for a collection of some size.

Assuming a large volume of documents is donated to the regional partners, the next challenge is scanning them into digital images. This represents a non-trivial cost. While a partner such as Google books could be approached to help manage this, scanning these documents using hired assistants would be costly and slow. A complementary approach to collecting digitized documents in an online archive is to provide a facility on the site for donors to upload their own documents. Prior experience with VCS projects

[8] http://history.msfc.nasa.gov/vonbraun/vb_weekly_notes.html

indicates that this approach can lead to a large volume of high-quality contributions.

Once the documents are collected, digitized, and uploaded to a virtual archive, it cannot be assumed that the materials are not the copyright of a third party. While personal notes of a donor can be posted on a website, perhaps even posted with a Creative Commons licence, there are several categories that raise potential copyright questions:

- Published books in the donor's library will most likely be the copyright of the publisher or author.
- Copyright for official documents will likely be held by the government that published them.

For documents that are not considered published, there is some ambiguity as to whether permission to poste documents in the possession of the donor can be granted by the donor. Such documents may include:

- Internal memos that were intended as transitory communications, including any hand-written annotations.
- Briefing notes and Cabinet Submissions, in various draft stages.

Documents covered by copyright may constitute "fair dealing" for digitizing and posting to a research-oriented website,[9] though whether a similar ruling would apply in the Canadian context is unclear (Geist 2012).

4. PROOF OF CONCEPT

Using the Zooniverse "build a project" framework, a proof-of-concept site was created.[10] A small number of test documents were uploaded, and a workflow based on several tasks created. Volunteer participants are asked to:

- Categorize documents: what type are they (several types available + other)?
- Triage: is there anything of interest (yes or no)?
- Prioritize: on a scale of 1-10, how important is the document?
- Digitize: correct OCR, interpret hand-writing.
- Interpret annotations: link to printed text; identify author.
- Link draft documents with later versions
- Trace evolution of documents
- Find demographic and career data of author and named individuals.
- Identify network data for persons and papers (e.g., work relationships).
- Evaluate, interpret, and analyze documents.

5. ROADMAP

Full deployment of this proposed collaborative project will require engaging a number of regional partners, accumulating records into local repositories, digitizing them and creating a central collective repository, and deploying a VCS user interface to allow current scholars and students of Canadian public management and public policy, and interested citizen analysts, to add value to the digital versions of original documents through their own reading and annotation processes, leading to a common cultural resource and supplement for future scholarship and practice. The prototype VCS site will require further development and usability testing prior to wider launch.

6. REFERENCES

Benkler, Y., Nissenbaum, H. (2006). Commons-based Peer Production and Virtue. *Journal of Political Philosophy* 14(4): 394-419.

Bowser A, Hansen D, He Y, Boston C, Reid M, Gunnell L, Preece J. (2013). Using gamification to inspire new citizen science volunteers. In *Proceedings of the First International Conference on Gameful Design, Research, and Applications* (pp. 18-25). ACM.

Bowyer, A., Lintott, C., Hines, G., Campbell, A., Paget, E. (2015). Panoptes, a Project Building Tool for Citizen Science. *Conference on Human Computation & Crowdsourcing, November 8-11 2015, San Diego. Association for the Advancement of Artificial Intelligence*.

Bush, V. (1945). As We May Think. *The Atlantic Monthly,* 176(1): 101–108.

Eveleigh A, Jennett C, Lynn S, Cox AL. (2013). I want to be a captain! I want to be a captain!: gamification in the old weather citizen science project. In *Proceedings of the First International Conference on Gameful Design, Research, and Applications* (pp. 79-82). ACM.

Geist, M. (2012). Supreme Court of Canada on Fair Dealing. http://www.michaelgeist.ca/2012/08/scc-on-fair-dealing/

Gray J, Liu DT, Nieto-Santisteban M, Szalay A, DeWitt DJ, Heber G. (2005). Scientific data management in the coming decade. *ACM SIGMOD Record*, **34**(4), 34-41.

Gribben, A. (1986). Private libraries of American authors: Dispersal, custody, and description. *Journal of library history*, 300-314.

Iacovides I, Jennett C, Cornish-Trestrail C, Cox AL. (2013). Do games attract or sustain engagement in citizen science?: a study of volunteer motivations. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems* (pp. 1101-1106). ACM.

Jackson CB, Østerlund C, Mugar G, Hassman KD, Crowston K. (2015). Motivations for Sustained Participation in Crowdsourcing: Case Studies of Citizen Science on the Role of Talk. *48th HICSS*. IEEE.

Kanefsky B, Barlow NG, Gulick VC. (2001). "Can Distributed Volunteers Accomplish Massive Data Analysis Tasks?" *Lunar and Planetary Science XXXII* (2001) 1272-1273.

Mintrom, M. (2007). The Policy Analysis Movement. Chapter 6, pp. 145-162 in Dobuzinskis, L., Laycock, D. H., & Howlett,

[9] In April 2016, the United States Supreme Court declined to hear a challenge from the Authors Guild and other writers claiming Google's scanning of their books amounts to copyright infringement and not "fair use" (the parallel concept in Canada is "fair dealing"). In June 2015, the 2nd US Circuit Court of Appeals ruled that Google could scan books and post to a website even though copyright was owned by someone else. See http://arstechnica.com/tech-policy/2016/04/fair-use-prevails-as-supreme-court-rejects-google-books-copyright-case/

[10] https://www.zooniverse.org/projects/jsgs/cppmemex

M. *Policy analysis in Canada: The state of the art*. Toronto: University of Toronto Press.

NASA. (2009). Request for Information Regarding the Weekly Notes of Dr. Wernher von Braun. Ref # NNH09CAO002L. June 25, 2009. National Aeronautics and Space Administration, Space Operations Mission Directorate.

Nicholson, J. R. (2010). Making personal libraries more public: A study of the technical processing of personal libraries in ARL institutions. *RBM: A Journal of Rare Books, Manuscripts and Cultural Heritage*, 11(2), 106-133.

Nov O, Arazy O, Anderson D. (2011a). Dusting for science: motivation and participation of digital citizen science volunteers. In *Proceedings of the 2011 iConference* (pp. 68-74). ACM.

Nov O, Arazy O, Anderson D. (2011b). Technology-Mediated Citizen Science Participation: A Motivational Model. In *Proceedings of the Fifth International AAAI Conference on Weblogs and Social Media* (pp. 249-256). Association for the Advancement of Artificial Intelligence.

Nov O, Arazy O, Anderson D. (2014). Scientists@Home: What Drives the Quantity and Quality of Online Citizen Science Participation? *PLoS ONE* **9**(4): e90375.

Reed J, Rodriguez W, Rickhoff A. (2012). A framework for defining and describing key design features of virtual citizen science projects. *Proceedings of the ACM iConference*: pp. 623-625.

Reed J, Raddick MJ, Lardner A, Carney K. (2013). An exploratory factor analysis of motivations for participating in Zooniverse, a collection of virtual citizen science projects. *46th HICSS*:610-619. IEEE.

Rotman D, Preece J, Hammock J, Procita K, Hansen D, Parr C, Lewis D, Jacobs D. (2012). Dynamic changes in motivation in collaborative citizen-science projects. *CSCW Proceedings of the ACM*: 217-226.

Shirky C. (2010). *Cognitive surplus: Creativity and generosity in a connected age*. New York: Penguin.

Wiggins A, Crowston K. (2011). From conservation to crowdsourcing: A typology of citizen science. *44th HICSS* (pp. 1-10). IEEE.

.