Leveraging Transmedia Communication Strategies to Improve Engagement and Foster Collaboration in Citizen-Science Projects

By
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A thesis presented to the Independent Studies Program of the University of Waterloo in fulfilment of the thesis requirements for the degree Bachelor of Independent Studies (BIS)

Waterloo, Canada
2017

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ABSTRACT

Citizen science is the term used for the practice of harnessing non-expert, volunteer efforts to further scientific research—using a *crowdsourcing* approach to collect, record, and analyze data and to fulfill other task work related to research. Maintaining enough interest and motivation to sustain participant engagement and involvement presents a challenge for project organizers. Current research indicates that a large percentage of participants contribute enthusiastically to citizen-science projects for a short period of time, only to lose interest, disengage from the project, and stop contributing. However, communication strategies can counteract some volunteer attrition by continually underscoring the importance and value of their contributions, and by raising a project's profile to keep it top-of-mind, relevant, and interesting to participants.

This thesis explores how citizen-science projects could apply or adapt transmedia storytelling, communication and engagement techniques—particularly in a context similar to documentary filmmaking—in order to reward contributors with a positive, integrated media experience to bolster engagement with the subject matters and the goals of long-term research projects. It will examine the history of public participation in science, the history of modern participatory culture, and how new media strategies can by applied toward a top-down, novice-level, biological- and environmental-monitoring project (the most abundant type of project in citizen science.)

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INTRODUCTION: PARTICIPANT INVOLVEMENT IN CITIZEN SCIENCE

Citizen science refers to the deliberate practice of engaging capable volunteers from the general public in processes of scientific enquiry, usually in a co-operative partnership with professional scientists and researchers. It refers to both top-down initiatives, where professional scientists and researchers recruit volunteer assistance, as well as bottom-up, grassroots efforts where citizen groups address community questions and concerns.

Publicly collected data has contributed to scientific research for hundreds of years—for example, grape harvest days in France can be tracked back for 640 years due to the records kept by vineyards—and highly motivated amateur experts specifically recruited peers and teams of non-experts to record observations of natural phenomena for the purpose of their own personal research projects.[1] However, it is more recently that more focused efforts to actively engage the public in research projects and recruit non-expert volunteers have become more commonplace, in part due to major advances in technology. The drive to include public participation in professional scientific research has become so widespread that the term “citizen science” was introduced into the OED in June 2014.

For projects to be successful, they must maintain contributor commitment in order to leverage “crowd science” as a resource—when a volunteer stops producing, it ends data channel and/or labor source. Chiara Franzoni’s quote below refers to the Old Weather project for which scientists had solicited the public’s help to transcribe weather observations and ship movements from logbooks made by Royal Navy Ships during World War I.

> *"In many crowd science projects, the majority of participants make only small and infrequent contributions, often stopping quickly after joining. . . . We see that a small number of individuals made a very large number of contributions. . . . Thus, mechanisms to increase the involvement of less frequent contributors may dramatically increase the amount of work a project can get done. At this point, it is not clear what process generates the observed uneven distribution of contributions. One possibility is that most contributors realize shortly after joining that the project is not a good match with respect to their skills or interests. However, we suspect that there are also important mechanisms that get people “hooked” over time and through which some of the nonpecuniary motivations discussed earlier become reinforced for some people but not others. Future research on these issues is clearly important."*[2]

The goal of the project was to digitize the data into a database that could be accessed for the development of more accurate climate models.

Philip Brohan, a climate scientist at the Met Office Hadley Centre who is a part of the Old Weather transcription project, compiled the contributory statistics for the Old Weather Blog and presented it in the following chart (Fig. 1). Each box represents the amount of work done by an individual contributor to the project. The Old Weather project successfully transcribed 1,090,745 pages of Royal Navy logs. It had 28,782 volunteers register on their website to take part in the project. However, the number of volunteers who actually took part and contributed at least one, single page of transcription is 16,400—57% of those who had signed on. Furthermore, when

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1 Miller-Rushing, Abraham, Richard Primack, and Rick Bonney. "The History of Public Participation in Ecological Research." *Frontiers in Ecology and the Environment* 10.6 (2012): 285-90. *ESA Journals - The Ecological Society of America's History and Records*. Ecological Society of America, 1 Aug. 2012. p. 286

2 Franzoni, Chiara and Henry Sauermann. "Crowd Science: The Organization of Scientific Research in Open Collaborative Projects." *Research Policy* 43.1 (2014): 1-20. *ScienceDirect*. Elsevier, Feb. 2014. p. 15

you examine the proportion of the boxes in the chart, it becomes apparent that a comparatively small number of people completed an enormous amount of work.

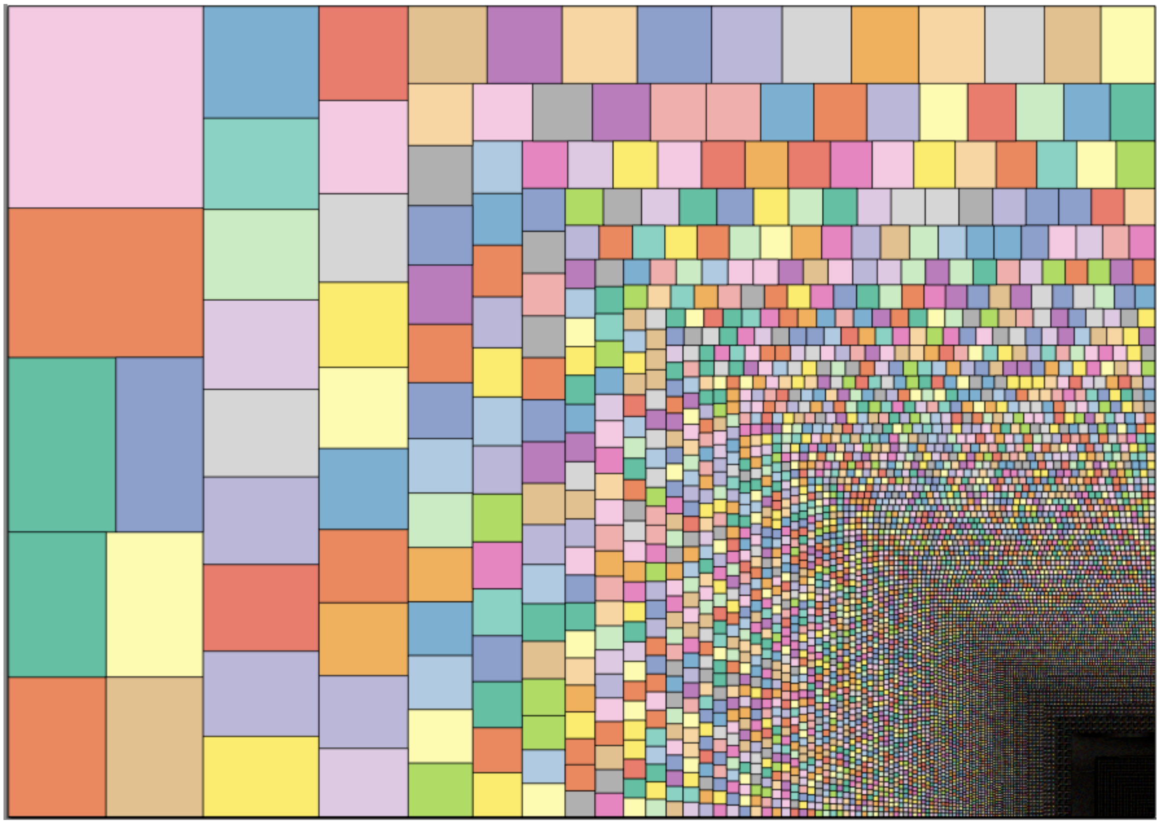

Fig. 1 – Work distribution for contributors to the Old Weather – WWI Royal Navy Logbooks project. Each box represents one contributor. The area of each box is proportional to the amount of work completed.[3]

While current research into the value and mechanisms behind citizen science underscore the value of sustaining participant involvement and engagement, there seems to be little research on *why* contributors abandon projects, and few recommended guidelines for *how* project designers can improve contributor engagement and retain talent.

The UK Environmental Observation Framework (UK-EOF) is an organization launched in 2008 to address issues in environmental monitoring that include data access and fragmentation. In their 2012 study, Understanding Citizen Science & Environmental Monitoring, they underscored the importance of volunteer motivation, but their published guidelines and best practice recommendations lack depth and strategic-planning guidance beyond basic approaches more commonly seen at a grassroots level.

> *One key insight, highlighted throughout studies considering the motivation of participants, was the importance of maintaining strong links between the data and data providers, both for conceptualising the research but also for encouraging future participation. This can take many forms from feedback and incentives to involvement in data analysis and interpretation. Many citizen science initiatives use spatial maps to display data as it arrives and so provide immediate information on how the participants' contributions are*

[3] Brohan, Philip. "There's a Green One and a Pink One and a Blue One and a Yellow One." Web log post. Old Weather Blog. Old Weather Project - Zooniverse, 5 Sept. 2012. Web. 24 May 2016. <https://blog.oldweather.org/2012/09/05/theres-a-green-one-and-a-pink-one-and-a-blue-one-and-a-yellow-one/>

closing gaps in knowledge (Hill, Guralnick, Smith et al., 2012). Incentives such as digital badges (for example used in Notes from Nature *and* iSpot*) can be assigned in recognition of specific achievements. However, rigorous studies exploring the effectiveness of badges as incentives to enhance citizen science motivation and continued contribution have yet to be conducted (Hill et al., 2012). Several projects also use new media (e.g. blogs, and increasingly social media) to continue communication with participants.*[4]

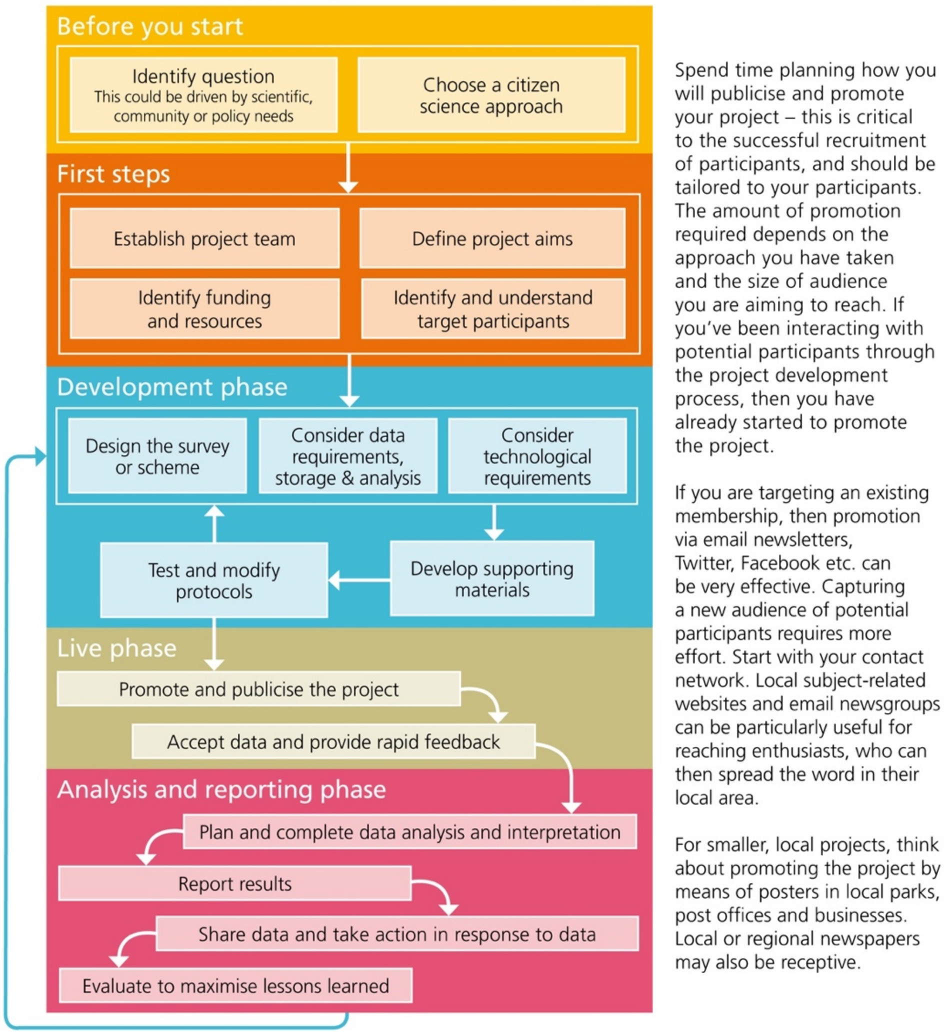

Fig. 2 – From the Guide to Citizen Science: citizen-science project flow chart and limited guidance for publicizing the project. Note there are no guidelines or best practices for sustaining participant engagement.[5]

This suggests a disconnection between the science community and media/communication specialists. The science community of UK-EOF acknowledges that projects can leverage new media, but does not have the scope or expertise to offer advice on *how* integrated media experiences can enrich participant satisfaction and improve project engagement. Common reasons for project abandonment cited by Dana Rotman et. al. in their *iConference 2014*

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[4] Roy, H.E., Pocock, M.J.O., Preston, C.D., Roy, D.B., Savage, J., Tweddle, J.C. & Robinson, L.D. *Understanding Citizen Science & Environmental Monitoring.* Final Report on Behalf of UK-EOF. NERC Centre for Ecology & Hydrology and Natural History Museum. n.p. 2012. p. 12.

[5] Tweddle, J.C., Robinson, L.D., Pocock, M.J.O.& Roy, H.E. Guide to Citizen Science: Developing, Implementing and Evaluating Citizen Science to Study Biodiversity and the Environment in the UK. Natural History Museum and NERC Centre for Ecology & Hydrology for UK-EOF. N.p.:n.p, 2012. p. 6 and 21.

presentation "Motivations Affecting Initial and Long-Term Participation in Citizen-science projects in Three Countries" include: frustration with task complexity, the lack of feedback, and competing commitments for time.

While current guides for citizen science recommend using email newsletters, Twitter, Facebook and other new media tools, they do not provide guidelines or best practices for the effective use of those tools. if project organizers are not using traditional or new media communications tools effectively, they are not responding to volunteer concerns or needs, and are not developing the strong ties between the project and participants that are needed to stimulate volunteer interest enough to overcome competing demands for time.

This paper, *Leveraging Transmedia Communication Strategies to Improve Engagement and Foster Collaboration in Citizen-Science Projects*, aims to explore how new media—specifically transmedia communication techniques and multi-media strategies—can be adapted and used to bolster engagement and participation with novice level citizen-science projects.

This paper will review the history of public participation in science, the structure of citizen-science projects, and the drivers that motivate volunteers to take part. It will then examine modern participatory culture and the influence of new media, and how non-fiction and documentary films have been able to effectively use narrative and transmedia communication strategies to support additional research, content creation, and engagement. I will then evaluate an entry-level, biodiversity, citizen-science project, and suggest how these strategies may be applied to the case study in order to reduce volunteer attrition and improve public and volunteer engagement.

1. OVERVIEW OF CITIZEN SCIENCE

1.1 History of Public Participation in Scientific Enquiry

To understand the collaborative role of the general public and science, one must take into account the sociological function of modern science today. The emergence of *scientist* itself as a formal, accredited profession is an invention of the late 19th century.[6]

Early studies corresponding to what we would consider science today fell in the domain of philosophy. *Natural philosophy* was the broad term for the systemic study of natural phenomena and the physical world. Largely theoretical and descriptive, natural philosophy spanned from before Aristotle until the 19th Century, by which time empirical science and the standards of the scientific method had emerged and become firmly entrenched.

The pursuit of knowledge about the natural world was straightforwardly a pursuit of the inquisitive. The study of the natural world was not only open to academics, but also well-read individuals who covered the costs of their own interests or sought out the patronage of the wealthy for research and development. Most avenues of groundbreaking research were conducted by amateurs—those who were not paid for their expected contributions to research. They were individual inventors and passionate naturalists funding their own research.

Those who studied the properties of the physical world were *men of science* and *philosophers*. Any delineation between expert and layperson was related more to class and social status: the gentleman versus. the labourer. In fact it has been suggested that "gentleman amateurs" of the time may have had more credibility as independent researchers than natural philosophers working under the auspices of kings, politicians, or religious orders—researchers who could be subject to the biases and political agendas of their patrons.[7]

As new scientific discoveries and advances in technology during the industrial revolution in the 18th and 19th century raised the profile of science and engineering, the study of physical science was becoming more prestigious. The role scientists played as experts and advisors found a new appreciation among the general public. Men of science were adopting titles such as *natural historian*, *natural philosopher* or *experimental philosopher* to distinguish themselves from studies that pursued avenues of thought related to ethics, metaphysics, and epistemology.

The term *scientist* was jokingly introduced by William Whewell in his anonymous 1834 review of Mary Somerville's *On the Connexion of the Physical Sciences.*[8] Not expecting it to be taken seriously, he proposed it as an umbrella term in line with words such as *economist* and *atheist* that avoided the "undignified compounds as *nature-poker*" (referring to the then-contemporary German expression *natur-forscher* to describe practitioners of scientific investigation). Later, feeling that it may actually have genuine merit, Whewell more legitimately reconsidered his proposal in his *Philosophy of the Inductive Sciences:*

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[6] Cahan, David. *From Natural Philosophy to the Sciences: Writing the History of Nineteenth-Century Science*. Chicago: U of Chicago, 2003. Print.

[7] Vetter, Jeremy. "Introduction: Lay Participation in the History of Scientific Observation." Science in Context 24.02 (2011): 127-41. Web.

[8] Ross, Sydney. *Nineteenth-century Attitudes: Men of Science*. Dordrecht: Kluwer Academic, 1991. Print. p. 9

"We need very much a name to describe a cultivator of science in general. I should incline to call him a Scientist. Thus we might say, that as an Artist is a Musician, Painter, or Poet, a Scientist is a mathematician, Physicist, or Naturalist."[9]

As the challenges and paths of inquiry became more complex the field of scientific study became more compartmentalized into specializations (e.g., biology, chemistry, and physics), and later further sub-specializations (e.g., under the rubric of biology: microbiology, toxicology, virology, etc.).

Meanwhile, interest-based societies had slowly started to make appearances in the mid-1600s, founded by eminent natural philosophers. The Royal Society, founded in 1660, being one of the first and foremost and having been granted Royal Charter. Similar organizations grew much more abundantly in the 19th century as modern science was taking shape, such as Germany's Gesellschaft Deutscher Naturforscher und Ärzte (1822) the British Science Association (1831), the American Association for the Advancement of Science (1848), Royal Canadian Institute (1849), and the U.S. National Academy of Sciences (1863).

It was during this latter period—the mid-to-late 19th century—that the existing scientific community started to reform the notion of "expert" to identify qualities and attributes one should have to be a subject-matter authority: training, skills, expertise, and sound practices. This culminated in the professionalism of science in that late 19th century and early 20th century—what Vetter refers to as a hardening of the demarcation between expert and layperson.[10]—and the development of disciplinary bodies for governance and standard-setting, which evolved from earlier amateur associations and societies and academic colleges.

Experts Only: The Institutionalization of Science

With the turn of the century, science became more centralized, institutionalized and insulated from the general public's input and scrutiny. Further conceptually isolating the experts from non-experts—tinkers, the intellectually curious, and do-it-yourself inventors for whom science was a pursuit of leisure—was the concurring expansion of the modern military-industrial complex.

Aviation pioneers Orville and Wilbur Wright, made their first, historic flight in 1903 and developed their fixed-wing plane design between 1904-05. Although they had both attended high school, neither one had fulfilled the requirements to receive a high school diploma, must less a post-secondary education that affiliated them with any recognized institution.

Within a decade of their first successful flight, the United States Congress had founded a federal agency, the National Advisory Committed for Aeronautics (NACA), specifically to institutionalize aeronautical research. The predecessor of NASA, its function was ostensibly to promote and coordinate aviation research, but was more plausibly implemented to help the U.S. play catch-up with European nations that were outpacing the American military with respect to airplane development and deployment in World War I.[11] (The Canadian equivalent was the Honorary Advisory Council on Scientific and Industrial Research founded in 1916).[12]

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9 William Whewell, *Philosophy of the Inductive Sciences, founded upon their History,* London, Vol. 1, p.cxiii. (as seen in Nineteenth-Century Attitudes: Men of Science By S. Ross p. 10

10 Vetter, Jeremy. "Introduction: Lay Participation in the History of Scientific Observation." Science in Context 24.02 (2011): 127-41. Web.

11 Suckow, Elizabeth. "National Advisory Committee on Aeronautics (NACA)." *NACA Home*. NASA History Program Office, 21 Apr. 2009. Web.

12 History." *Royal Canadian Institute*. N.p., n.d. Web. 08 Jan. 2017.

On the one end of the spectrum were the Wright brothers, consummate "amateur experts" who were private citizens with a passion for innovation and flight and no direct ties to the formal scientific/academic community. On the other was the seemingly rushed development of one of the founding government-science interface programs.

While *military–industrial complex* was a term coined by outgoing President Dwight D. Eisenhower during his 1961 farewell address, the amalgamation of public and private sector research and development (R&D) in industry and the military had been expanding rapidly as warfare had been becoming more industrialized and mechanized during the latter half of the 19th century.

The world saw an accelerated period of technological and scientific innovation during the World Wars as more funding was invested in R&D and partnerships formed with corporations, institutions, and research facilities supplying the military. The scientific community became more deeply embedded in policymaking as advisor and contributor to the government-military-industrial engine, expanding its scope from its formal roots in academia.

In the U.S., President Harry S. Truman established the National Science Foundation "To promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense."[13] The National Science Foundation's historical overview, available on their website, explains:

> *The American people recognized that scientists and engineers had helped win World War II. Penicillin and the atomic bomb were but the two best known of the many contributions made by the research community. With the coming of peace, the challenge facing politicians and researchers alike was how to ensure that science and engineering would continue both to expand the frontiers of knowledge and serve the American people. The answer was the National Science Foundation (NSF), established in 1950, which continues to be the only federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines.*[14]

This marked the point where a scientifically literate general public was recognized as an important asset for to economic growth, industrial advancement, innovation and progress.

Non-Expert Contributions: Public Participation in Scientific Research

The notion of *scientific community* has its foundation in the societies like the Royal Society where early membership included amateurs—the Royal Canadian Institute opened its membership "…to those whose pursuits or studies were of a kindred character"[15] and whose membership remains open to the public today—and organizations like the International Association of Academies (1899-1914) where all members were scholars with credentials from learned societies. Most scientific societies intended for professional-level scientists have membership dependent on educational credentials, employment, and publication record. Science had become a field with high barriers to entry and access to information.

However, during the same period in which professional scientific and disciplinary associations were growing and shaping science as an accredited profession, so too were the amateur

[13] "National Science Foundation - Where Discoveries Begin." *NSF - National Science Foundation*. N.p., n.d. Web. 08 Jan. 2017.
[14] "National Science Foundation - Where Discoveries Begin." *NSF History | NSF - National Science Foundation*. N.p., n.d. Web. 08 Jan. 2017.
[15] "History." *Royal Canadian Institute*. N.p., n.d. Web. 08 Jan. 2017.

societies for whom scientific pursuits were leisure activities. Barriers to entry were few and depended mainly on areas of interest and occasional membership fees. Astronomy, entomology (chiefly butterflies), botany, and ornithology in particular were popular areas of enquiry for societies of amateurs and hobbyists. Lay people continued to be involved in scientific enquiry, working for experts, or actively collecting data and cataloguing observations as part of their own personal studies of observable phenomena. Despite the professionalization of the field, amateur participation in scientific pursuits did not wane, but rather continued to flourish in these community groups.

Informal networks for sharing observational data have existed for centuries particularly in industries and for communities whose livelihoods are heavily dependent on natural phenomena like weather patterns, soil conditions, and animal migration patterns —hunting, farming, and fishing. Wine growers in France have been recording grape harvest days for centuries, and in China locust outbreaks have been recorded for millennia.[16]

So the informal frameworks for collecting and sharing observational information have existed for thousands of years, but a new element was introduced with the expansion of these science-based community groups. These astronomy and naturalist groups created and provided a *social context* for science that remained distinct from the professionalized realm and could be considered an early iteration of participatory culture that long pre-dates digital social media to which we tend to ascribe the rise of participatory culture today.

Astronomical Society of the Pacific as an example was founded 1889 by a group of over thirty individuals that included a high school science teacher, a college professor, a civil engineer, a professional astronomer, a corporate lawyer, a railroad clerk, an insurance broker, and a homeopathic physician—a very diverse group of people sharing a common interest in the stars.[17] The organization continues to thrive today as an international non-profit organization that has partnerships with professional and educational organizations, such as NASA. Some of its better known, past members include: photographer Ansel Adams and authors Isaac Asimov, Arthur C. Clarke, and Larry Niven.

While non-professional members of public may take part in personal research to further their own interests, the social/community element of taking part in a larger group project became a strong incentive for amateurs involved with like-minded peers in these scientific societies. So when the National Audubon Society launched its annual Christmas Day bird count in 1900 it became a major social event of the season (open to both members and non-members) and is currently one of the longest running citizen-science projects in North America.[18]

Another important motivator for the public pursuit of science came about in reaction to the siloing of science. When scientific and technological research became institutionalized in academia, the military-industrial system, and private sector facilities (such as those of the pharmaceutical industry) it was insulated from openly public oversight and participation, and became somewhat shielded from community watchdog groups to protect intellectual property rights in competitive industries. Examples can be seen today in the pharmaceutical and software industries where public access to information (such as chemical composition or source

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[16] Miller-Rushing, Abraham, Richard Primack, and Rick Bonney. "The History of Public Participation in Ecological Research." *Frontiers in Ecology and the Environment* 10.6 (2012): 285-90. *ESA Journals - The Ecological Society of America's History and Records*. Ecological Society of America, 1 Aug. 2012. Web. p 286

[17] Bracher, Katherine. "The Stars for All: A Centennial History of the Astronomical Society of the Pacific." *Mercury Magazine* Sept. 1989: p. 4. Print. Published by the Astronomical Society of the Pacific, San Francisco, CA.

[18] "The History of Audubon." *Audubon*. National Audubon Society, 15 May 2015. Web. 28 Sept. 2016.

code) is limited in order to guard proprietary information and trade secrets. Meanwhile scientific advisory committees and science/technology government agencies helped steer top-level government policy decisions that affected the public constituencies they represented.

In response to professional science's growing advisory role in policy-making, community science grew with grassroots initiatives and public non-governmental organizations (NGOs) that were linked to social change and activism, as well as organizations engaged in public consultation. Examples are politicized ecological issues and environmental activism where community science projects were part of lobbying initiatives to influence policy development—water and air quality, effects of industrial pollution—and to challenge the official reports or data that were unsupported by communities' independent research findings.

The community-activism approach to citizen science has been notably important in issues of patient advocacy. A compelling example can be found in the AIDS crisis during the 1980s, when the penetration of very well-informed activists into the biomedical science arena had enormous, long-lasting impacts on the "the design, conduct, and interpretation of the clinical trials used to test the safety and efficacy of AIDS drugs" and radically changed the credibility of laypeople as research participants.[19] The LGBTQ community was able to leverage existing social-movement networks and resources—already prepared to mobilize against threats to the community—and collect and verify statistics on clinical trials and health outcomes as well as challenge credentialed experts and regulators on issues of patients' access to experimental drugs and therapies.

Emergence of Citizen Science and Crowdsourcing Scientific Research

For the most part, public participation in science has been cooperative rather than adversarial. The scientific community has long relied on public cooperation and support from lay observers in as a part of their research processes, primarily in ecological and environmental fields—from accessing and re-interpreting historical data sets, such as growers' logs, weather observations, and amateur associations' environmental-based observational data (astronomy, bird and butterfly counts etc.), to government-collected statistical information (census data, labor data) and public health initiatives.

The pervasiveness of amateur associations and informal knowledge-sharing and data-collection networks (like the previously mentioned logs from wine growers in France) is why it is virtually impossible to pinpoint an exact timeline for the emergence of citizen science/crowdsourcing science. Data-gathering frameworks have always existed in various forms depending on the needs of communities (e.g., agricultural) and leisure/social interests, but it was a matter of time before the scientific community truly acknowledged and embraced the potentials of formally taking advantage of these informal resources.

So the idea of citizen science as a purposeful, active and collaborative partnership between experts and the general public is relatively new. The term *citizen science* itself was coined by Rick Bonney in 1995 and introduced into the Oxford English Dictionary as recently as June 2014.[20] As a concept, it developed in tandem with science-literacy initiatives[21] and by

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[19] Epstein, Steven. "The Construction of Lay Expertise: AIDS Activism and the Forging of Credibility in the Reform of Clinical Trials." *Science, Technology, & Human Values* 20.4 (1995): 408-37. Web.

[20] Bonney, Rick, Heidi Ballard, Rebecca Jordan, Ellen McCallie, Tina Phillips, Jennifer Shirk, and Candie Wilderman C. Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report. Washington, DC: Center for Advancement of Informal Science Education (CAISE), 2009.

[21] Bell, Philip. *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington, D.C.: National Academies, 2009. eBook. p. 16.

recognizing that some research questions could be approached more effectively if simple tasks could be delegated to large numbers of people.

For example, the original, 1958, Baby Tooth Survey[22] was a study by researchers at Washington University in St. Louis that asked the citizens of St. Louis, Missouri to send in their children's baby teeth to study the effects of fallout radiation from nuclear testing conducted by the U.S. from 1945 to 1963.[23] Hundreds of thousands of baby teeth were donated to the program before it was concluded in 1970. Findings led to an end of above-ground nuclear testing in 1963. The success of this study and others—being able to foster broad public cooperation—demonstrated the potential of using the public for large-scale data/specimen collection with the added benefit of providing learning opportunities that could improve scientific literacy for the general public.

By actively and purposefully taking part in scientific research experiences, the volunteers enrich their knowledge and skill sets beyond what could be developed through passive learning as in a classroom or lecture setting. This allows them to be better informed about scientific concepts and reasoning, improve their critical thinking skills, and their awareness of scientific issues. Meanwhile professional researchers can meet objectives that could not be achieved without widespread, voluntary public assistance.

Over the last 30 years, theories for informal science education have evolved and communication technology has made it easier for researchers to leverage public participation as a tool while teaching participants the skills they need to be effective contributors. Within the last decade, the number of citizen-science projects started increasing rapidly in conjunction with the growth and development of social media platforms and the rise of online, participatory culture and networking capabilities. So more effort has been put toward designing collaborative research projects—establishing protocols that plan for citizen participation, and take into account skill levels, margins for error, and data quality assurance—that can benefit both researchers and foster public interest in science and science education.

1.2 Organizational Modes of Participation

Citizen science shares many attributes of open, collaborative projects and peer production, however there are important key differences in the organizational control structures. Online participatory communities are largely democratic and coordinated by consensus, whereas citizen-science projects are by necessity organized and directed by a hierarchical leadership[24]—scientists directing lay people. It may be that the control structure contributes to participant drop-off as contributors find that their expectations for collaboration—derived from other participatory media experiences—are not well aligned with the organizational framework of the research study.

The often cited Center for Advancement of Informal Science Education (CAISE) inquiry group's 2009 study, *Public Participation in Scientific Research: Defining the Field and Assessing Its*

[22] Reiss, L. Z. "Strontium-90 Absorption by Deciduous Teeth: Analysis of Teeth Provides a Practicable Method of Monitoring Strontium-90 Uptake by Human Populations." *Science* 134.3491 (1961): 1669-673. Web.

[23] Lord, Alexandra. "The Tooth Fairy Goes Scientific." Web log post. *National Museum of American History (NMAH)*. Smithsonian Institution, 27 Apr. 2015. Web. 4 Sept. 2016.

[24] Wiggins, Andrea, and Kevin Crowston. "From Conservation to Crowdsourcing: A Typology of Citizen Science." In *Proceedings of the Forty-fourth Hawai'i International Conference on System Science (HICSS-44),* Koloa, HI. N.p.: n.p., 2011. N. pag. Web

Potential for Informal Science Education, identified three key categories for public-participation research projects: 1) contributory, 2) collaborative, and 3) co-created. These categories reflect the amount of control participants have in their roles in various investigative processes.

Categories of Public Participation in Scientific Research
1 – CONTRIBUTORY: Generally designed by scientists and for which members of the public primarily contribute data; also includes studies in which scientists analyze citizens' observations, such as those in journals or other records, whether or not those citizens are still alive.
2 – COLLABORATIVE: Generally designed by scientists and for which members of the public contribute data but may also help to refine project design, analyze data, or disseminate findings
3 – CO-CREATED: Designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all steps of the scientific process; also includes research wholly conceived and implemented by amateur (non-professional) scientists.

Table 1 – Categories of public participation in scientific research (modified from Miller-Rushing's adaptation of Bonney *et al.* 2009a)

In a 2012 article for *The Ecological Society of America*, authors Abraham Miller-Rushing, Richard Primack, and Rick Bonney adapted the categories into an easy-to-read explanatory table[25] displaying the category and its definition.

The table is suitable for describing both top-down research projects (those initiated and controlled by professionals) as well as bottom-up projects (those initiated by amateurs and members of the public where the control of the project is shared.)

Depending on the nature and level of complexity of the scientific inquiry, some research tasks or design elements may be outside the scope of knowledge of lay participants, or they may require specialized skills or tools. Referring to the Baby Tooth Survey mentioned earlier, any citizen could contribute a tooth to the study, but only a very small number of experts could isolate and analyze the radioactive isotope that was being sought—there are expert-level process and requirements that can not possibly include every participant.

In 2013 OpenScientist blogger, David Curren, further refined the categories to acknowledge the participation levels (per number of individual contributors or talent pool) that usually accompany each category.[26] In his blog, he postulates that each participation category *also* corresponds to certain levels of skill and expertise that would be required to fulfill key tasks at each level. Therefore, the number of possible participants would decrease as the avenue of inquiry or one of its components requires more and more specialized capabilities. He uses a pyramid diagram in his visual representation of the categories with the apex representing the tapering number of potential contributors who are able to fulfill the specialized roles and the broad base of the pyramid representing the much larger resource pool of non-experts.

He modifies the categories by linking them to levels of activity, involvement, and control. In my opinion, it is a more effective way to view/visualize the modal structure of participation, because it displays the hierarchical organizational structure (common to most top-down, citizen-science

[25] Miller-Rushing, Abraham, Richard Primack, and Rick Bonney. "The History of Public Participation in Ecological Research." *Frontiers in Ecology and the Environment* 10.6 (2012): 285-90. *ESA Journals - The Ecological Society of America's History and Records*. Ecological Society of America, 1 Aug. 2012. Web. 11 June 2016. p.286

[26] Curren, David. "The Levels of Citizen Science Involvement - Parts 1 and 2." Web log post. OpenScientist. N.p., 13 Jan. 2013. Web. 14 May 2016. <www.openscientist.org>.

projects) and more readily includes contribution processes that require very little effort. Curren's model adds as an additional category the contributions that come from distributed computing where volunteer involvement requires no more effort than downloading a program and letting it run. Additionally, we have entered the era of Big Data where vast amounts of data are passively and automatically collected through digital devices linked to the Internet. One can contribute to a study by simply allowing an app to access the data from one's personal fitness tracker or smartphone, for example—no ongoing intervention is needed.

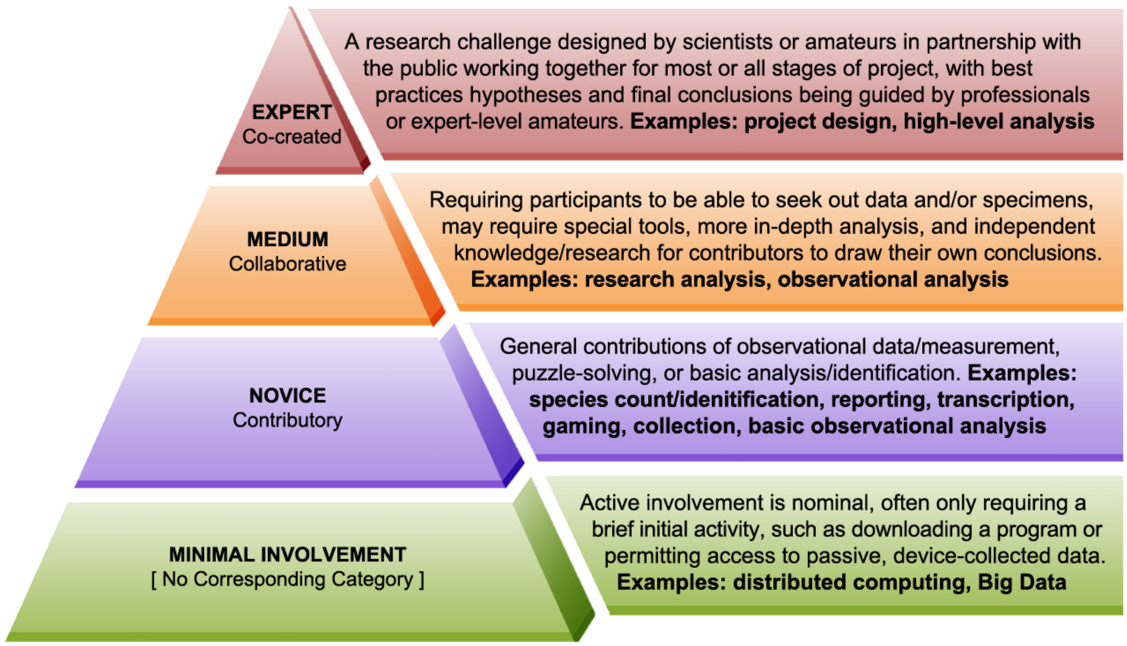

Fig. 3 – Citizen Science Categories and Participation Levels. (Adapted from Dave Curren, OpenScientist 13 Jan. 2013.)

Considering task complexity with respect to the categories of participation, one can also see that at high-levels of complexity where highly specialized skills (expert) are in greater demand the project can be considered "co-created" due to the interdependency of tasks and the full transparency required for the project to succeed. Success requires teamwork and constant collaboration.

In "Crowd Science: The Organization of Scientific Research in Open Collaborative Projects," Chiara Franzoni and Henry Sauermann discuss the relationship of task complexity and project openness. For "task complexity" they use the following definition: "Task complexity is best conceptualized as the degree of interdependency between the individual subtasks that participants perform when contributing to a project." [27]

Where the tasks are *not* complex, individual contributors can work fully independently and do not need to build upon the tasks or subtasks that are being provided by other contributors or different stages of the project. Here you can have participants at the novice/contributor level doing work by feeding data into a system that does not need to disclose evaluation processes, results, or other data inputs to those base-level contributors—they can do the job without knowing the big-picture context. Top-level creators organize the project plan and overall

[27] Franzoni, Chiara and Henry Sauermann. "Crowd Science: The Organization of Scientific Research in Open Collaborative Projects." *Research Policy* 43.1 (2014): 1-20. *ScienceDirect*. Elsevier, Feb. 2014. Web. 20 May 2016. Section 3.

contributor roles tend to be clearly defined, well programmed, and compartmentalized. This is where distributed data collection or transcription projects would fall.

By contrast, complex tasks build cumulatively on earlier steps or subtasks and rely on a greater degree of open access, transparency, and collaboration to move forward toward the project resolution. As an example, Franzoni and Sauermann point to the Polymath Project that issues open challenges to solve mathematical problems or proofs. In this case, a comprehensive project view and ongoing peer review is critical to progress and accuracy—it proceeds more organically—and the level of expertise required is much more sophisticated. Also, at such a level, the structure of project/problem cannot necessarily be pre-determined or programmed, and contributor tasks cannot be easily compartmentalized. Each new task and the direction that the problem-solving process takes may be dictated by the successful completion and/or integration of other parts as they develop.

Looking at Curren's pyramid of participation categories, we can add "task complexity" to underscore the level of activity, involvement, and control. For the first Polymath Project challenge (Polymath1), only a few dozen mathematicians and subject-matter experts were intensely involved in all or most stages of a mathematical proof, co-authoring the solution.[28] In comparison, the Old Weather delegated the basic task of transcribing WWI Royal Navy logbooks to public contributors resulting in *16,400 individual contributors* transcribing 1,090,745 pages.[29] The climate data is processed by scientists at the Met Office Hadley Centre for Climate Science and Services for inclusion into databases of historical weather records used for climate research.

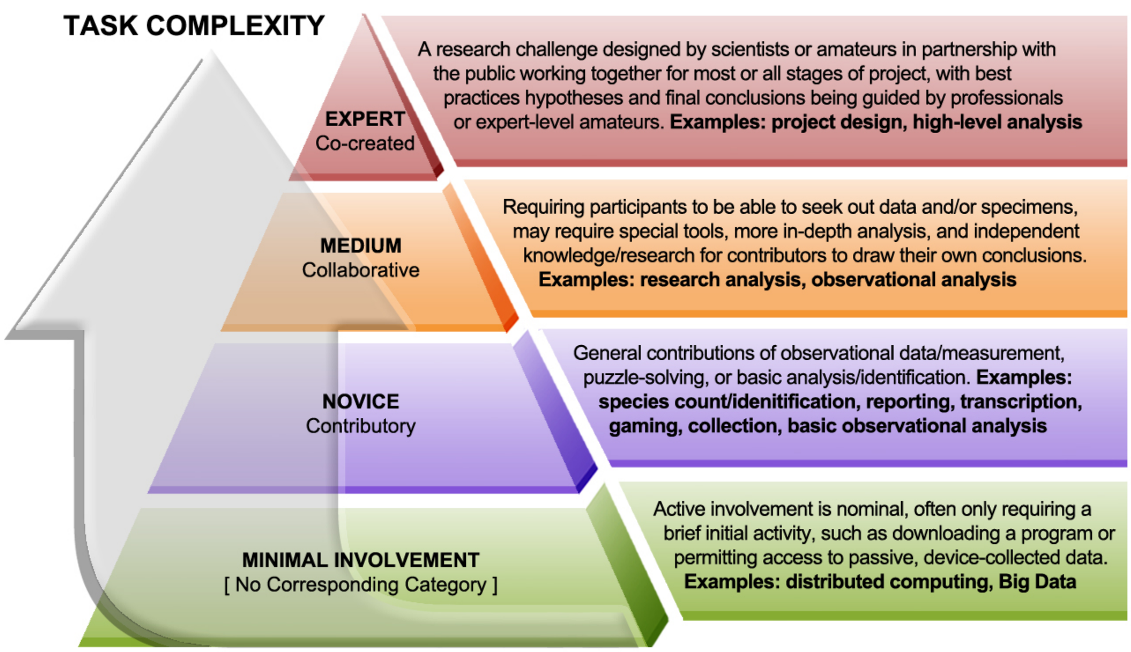

Fig. 4 – The increase of task complexity and interdependency at different levels of participation.

All the organizational categories may contribute to a given project if it is so designed, with participants' roles determining the level of complexity at which they operate. An expert scientist

[28] Many of the Polymath challenges remain in a perpetual state of flux. Depending on the source, Polymath1 is listed as having the number of individual contributors ranging from 27-40. The solution was published under the collective pseudonym D.H. Polymath.
[29] Brohan, Philip. "There's a Green One and a Pink One and a Blue One and a Yellow One." Web log post. *Old Weather Blog*. Old Weather Project - Zooniverse, 5 Sept. 2012. Web. 24 May 2016.

may launch a sophisticated study as part of a thorough scientific inquiry, a team grad students use their skills to analyze data under the oversight and direction of the expert, and the raw data is provided by laypeople—the citizen scientists—according to protocols prescribed by the expert and facilitated by the grad students. The expert is involved at all stages and will be responsible for combining everything into a comprehensive report of results and conclusions, whereas the lay, citizen scientists focus only on basic tasks for data input: expert/creator, medium/collaborators, to novice/contributors.

1.3 Developing a Task-Based Project Typology: Practical Modes of Participation

Citizen-Science Typologies

For the *Forty-fourth Hawai'i International Conference on System Science* in 2011, Andrea Wiggins and Kevin Crowston presented their paper, “From Conservation to Crowdsourcing: A Typology of Citizen Science”. They had completed a comparative study of citizen-science projects in order to devise an empirically based typology of citizen-science projects. They base their study on a sampling of (mostly) “scientist-initiated” (top-down) projects that have/had professional researchers collaborating with general-population volunteers, and then assessed them against 80 facets for clustering.

> *The analysis process began with identifying a wide range of facets to describe citizen-science projects. The facets were drawn from a conceptual model we constructed to describe citizen-science projects, including inputs, processes and outputs at both the project and participant level. Given the exploratory nature of this work, the intent was to employ a very broad and inclusive set of characteristics for later revision with the addition of empirical evidence.*[30]

Their findings assign projects to five categories (very roughly summarized):

Action: Most often characterized by grassroots organization *not* initiated by a scientist in projects that support civic agendas or community activism and that require hands-on involvement in data collection and research with the goal of providing evidence for policy development or intervention. Examples: water quality concerns, challenges to zoning by-law amendments, and concerns about the local effects of industrial pollution. Often these projects are localized, but they can be a part of more widespread community activism initiatives as was seen with patient advocacy during the AIDS crisis.

Conservation: Characterized by data collection in support of ecological and natural resource management goals and volunteers are often collaborating with both scientists and regional and/or federal agencies on long-term monitoring assignments.

Investigation: Scientist-initiated projects with defined research goals that have tasks, such as data collection, that can be widely distributed nationally or even internationally. They have the potential for very large-scale participation and education is often a component or secondary goal. Biological research programs make up the bulk of projects in this category, along with environmental research (including climatology, astronomy).

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[30] Wiggins, Andrea, and Kevin Crowston. "From Conservation to Crowdsourcing: A Typology of Citizen Science." In *Proceedings of the Forty-fourth Hawai'i International Conference on System Science (HICSS-44),* Koloa, HI. 2011. p.5.

Virtual: Scientist-initiated projects with defined research goals like the Investigation category, but **". . .** all project activities are ICT-mediated [information/communication–technology-mediated] with no physical elements whatsoever, differentiating them from the Investigation projects in which the physical places of volunteer participation were also important."[31] Rather than collecting data locally, participants contribute to remote projects hosted on virtual platforms. For example, Old Weather's transcription project, or Galaxy Zoo's image–analysis-based galaxy classification project.[32]

I propose re-naming this category to "Remote/Virtual Participation" or "Remote/Virtual Investigation"—virtual technology *enables* and *facilitates* the process, but most non-gaming projects, such as transcription and identification projects, could have been accomplished pre-Internet with printed images, albeit at a much slower pace and a much higher cost. This would also prevent possible confusion that may result from the widespread adoption of Web infrastructure into citizen-science projects generally, such as those that ask citizen scientists to record local observational data into an online database through an Internet platform. The key component of Remote/Virtual Participation is that participants are logging in to and working on distant projects in a manner similar to students using distance-education frameworks.

Education: Projects are specifically designed as informal learning opportunities to supplement curriculum-based studies. Scientific research goals take a back seat to activities that foster the development of participant research and critical thinking skills.

One of the criteria used by this study to evaluate the projects is their organizational structure. They break it down to "top-down", "middle-out", and "bottom-up." Referring to Curren's pyramid, Investigation, Virtual, and Education would fall under the hierarchical structure of expert-initiated projects—top-down. The Conservation category is listed as "middle-out" as the projects are hierarchical, but often initiated and overseen by non-experts from government/public agencies in consultation with scientists/experts to ensure scientifically rigorous oversight. The Action category is unique in that it has a bottom-up approach. It is usually the result of members of the general public recognizing a need for scientific inquiry to provide empirical evidence to support community concerns. These projects are novice-initiated, but expert-level professionals may be recruited into the process to verify results and conclusions, complete high-level analysis or complex tasks, or fulfill tasks requiring specialized equipment.

This typology is useful for developing conceptual frameworks of citizen science that could be applied toward project-design considerations (that would include project objectives, technology infrastructure needs, and budget) and identifying some of the general motivators for participation that can make a given project appealing to would-be citizen scientists. However, it may not be as useful for identifying shifts in mood or motivation that result in volunteer drop-off as the typology does not zero-in to the practical aspects of volunteer engagement: what volunteers actually do and accomplish when they take part in a citizen science program.

Muki Haklay developed an activity-based typology for citizen science based on the activities of the contributor networks and that span across all contributor types, from novice to expert: *volunteer computing*, *volunteer thinking,* and *participatory sensing*[33]. Volunteer computing (distributed computing) as noted in Curren's activity-involvement-control pyramid, requires only

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[31] Wiggins page 7.

[32] The Galaxy Zoo project is an ICT-mediated project in which participants help researchers classify galaxies by sorting images taken by telescope into categories based on their visual appearance (elliptical, spiral, etc.) and other properties.

[33] Haklay, Muki. '"Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation". *Crowdsourcing Geographic Knowledge*. Ed. by D. Z. Sui, S. Elwood and M. F. Goodchild. Dordrecht, Netherlands: Springer. 2013. pp.4-6

a minimal, initial contact by a participant after which all contributions are fully automated. Volunteer thinking requires participants to make an intellectual effort and use reasoning abilities towards a research project's goals such as analyzing or classifying data or solving puzzles. Participatory sensing involves carrying out research tasks such as collecting samples or taking measurements—the "sensing" referring to technology-mediated data collection such as recording bird calls, photographing plant species, or recording GPS co-ordinates.

Haklay's model (which was based on Web-mediated contributions) has been proven to be more useful for analyzing motivational drivers[34] because it also covers the activity-level investment contributors could be expected to face (from low to high): volunteer computing requires a negligible time/work investment, volunteer-thinking tasks can often be fulfilled in the comfort of one's own home, and participatory sensing requires contributors to actively go out into their environments to collect data or record information.

Passive Contributions in Citizen Science

For the purpose of this thesis, passive contributions, such as volunteer computing/distributed computing, can be safely set aside because they require no ongoing participant engagement. However, for the sake of completeness and for future research consideration I am presenting a short overview and examples of passive citizen-science project types.

Distributed computing (what Haklay calls "volunteer computing") typically involves installing software programs onto personal computers. The programs run in the background leveraging volunteers' spare computer processing power with no user input or involvement required. The vast network of participating computers acts as a virtual supercomputer. Examples include the Search for Extra-Terrestrials at Home (SETI@Home) by the University of California - Berkeley[35]—one of the seminal distributed processing projects—that processes radio-wave signals from outer space to look for patterns that would suggest extra-terrestrial messages or signs of intelligent life, and Great Internet Mersenne Prime Search (GIMPS)[36] that looks for Mersenne prime numbers (primes that are one less than a power of two.) Other passive contributions include automatically collected data from personal devices—such as smartphones, fitness trackers, or dive computers—that contributors share through apps or by giving citizen science permission to access the collected data.

An additional form of contribution, worth mentioning tangentially to passive contribution, is a type of *ancillary contribution* where project participation is incidental to an unrelated goal—human intervention contributes valuable input to a research project, but only as a by-product of users' intentions. For example, challenge-response computer CAPTCHAs exist ostensibly to thwart malicious, automated programs (bots) that seek to exploit Web forms. Users are prompted with a familiar phrase such as "Prove you're not a robot!" and must perform a quick task such as deciphering text in an image, or identifying image content. Users' intentions are to fulfill security protocols that are beneficial to protecting their online accounts, but behind the curtain, software developers are leveraging human-eye perception to refine their image-recognition software and machine-learning systems. An example is Google's reCAPTCHA:

> *Millions of CAPTCHAs are solved by people every day. reCAPTCHA makes positive use*

[34] Jennett, Charlene, Laure Kloetzer, Daniel Schneider, Ioanna Iacovides, Anna Cox, Margaret Gold, Brian Fuchs, Alexandra Eveleigh, Kathleen Mathieu, Zoya Ajani, and Yasmin Talsi. "Motivations, Learning and Creativity in Online Citizen Science." *JCOM - The Journal of Science Communication*. SISSA Medialab, 20 Apr. 2016. p.3.

[35] "What Is SETI@home?" *SETI@home*. University of California, n.d. Web. 08 Jan. 2017.

[36] "Great Internet Mersenne Prime Search - PrimeNet." *2^P-1*. Mersenne Research, Inc., n.d. Web. 08 Jan. 2017.

of this human effort by channeling the time spent solving CAPTCHAs into digitizing text, annotating images, and building machine learning datasets. This in turn helps preserve books, improve maps, and solve hard AI problems . . . reCAPTCHA digitizes books by turning words that cannot be read by computers into CAPTCHAs for people to solve. Word by word, a book is digitized and preserved online for people to find and read.[37]

Millions of people are operating as citizen scientists in a global project every day without knowing it.

Common Modes of Active Contribution: What Do Citizen Scientists Actually Do?

Developing a typology based on practical modes of participation—how participants are involved, what they are expected to do to contribute, and how they interact with the project—is the approach I am taking in consideration of developing engagement strategies to recruit and retain citizen-scientist contributors. It should allow us to correlate task type with motivational drivers.

For this section, I will focus on volunteers from the general public and projects that do not require highly specialized equipment (eliminating for example, the Argus project[38] that asks sea captains to measure seabed depth with sonar equipment). I will focus on *active tasks,* which require deliberate engagement and commitment to an activity—whether volunteer thinking or participatory sensing—that are common to many types of citizen-science projects.

Transcription / Image Classification / Cataloging

Transcription projects and image classification are similar project types in that they require contributors to review digital images—such as scanned documents or photographs—and report their contents. In addition to scientific research problems, transcription projects have also been useful in the humanities for transcribing historical documents and literature.

The tasks require no specialized skills (other than sometimes great patience/diligence), knowledge, or formal education or training with respect to the project's subject matter or field of study. The project tasks are suitable for novice participation and often include humanities-based research projects (history and literature).

Examples:
Old Weather[39] - transcribing handwritten weather logs from navy ships and whaling vessels.
Galaxy Zoo[40] - classifying galaxies from images captured by telescope.
Smithsonian's Phyllis Diller Gag file [41]- transcribing 52,569 typewritten index cards of jokes.

Observational Measurement, Recording, and Data Collection

Contributors provide and log quantitative measurements that do not require additional analysis or reasoning skills. In most cases, no special tools are required and measurement-taking can generally be fulfilled using common, household tools such as yardsticks, thermometers, and

[37] "Invisible ReCAPTCHA." *Google*. Google, n.d. Web. 08 Jan. 2017.
[38] Franzoni, Chiara and Henry Sauermann. "Crowd Science: The Organization of Scientific Research in Open Collaborative Projects." *Research Policy* 43.1 (2014): 1-20. *ScienceDirect*. Elsevier, Feb. 2014. p. 11
[39] Brohan, Philip. "There's a Green One and a Pink One and a Blue One and a Yellow One." Web log post. Old Weather Blog. Old Weather Project - Zooniverse, 5 Sept. 2012. Web.
[40] "Galaxy Zoo - The Story So Far." Galaxy Zoo. The Zooniverse, n.d. Web. 17 Feb. 2017. <https://www.galaxyzoo.org/#/story>.
[41] BredenbeckCorp, Hanna. "Help Us Transcribe Phyllis Diller's Jokes—and Enjoy Some Laughs along the Way!" *National Museum of American History*. Smithsonian Institution, 1 Mar. 2017. Web.

recording may require only observations made with the naked eye. Some projects may also require collecting and submitting samples, either virtually (such as uploading photographs to an online database) or through a collection kit sent by mail. These tasks are also suited to novice participants and can be combined with educational program activities.

Examples:
Snow Tweets[42] - measuring snow depth with a ruler and broadcasting the results on Twitter.
Squirrel Mapper[43] - counting black and gray morphs of the Eastern Grey Squirrel.
Backyard ANTology[44] - kits and pre-paid envelopes are provided to collect ants to send as a one-time contribution to researchers.

Basic Observational Analysis / Identification Projects

These are medium-level project tasks that require more intellectual reasoning and some subject knowledge (which can be guided by the project designers). These more analytical tasks require citizen scientists to record observations or observational measurements, and also consider the data, make qualitative evaluations, and draw their own conclusions. Many of these projects are "identification/measurement" projects where citizen scientists record and identify (drawing a conclusion) plant or animal species. Participants may work independently, but often benefit from collaboration—both in terms of accurate results and social rewards—either in person (such as birding associations) or through online communities and discussion groups.

For example, many biodiversity projects collect data through online platforms such as iNatulralist.org. Any participant may upload a digital record, with or without a species identification—once uploaded and shared to the community, other participants can confirm/identify or discuss the species in the record.

These more analytical projects may be appropriate to novice contributors, but could require additional skills, knowledge, or tools such as a telescope or an insect field guide. Some medium-level analytical projects provide guidance and basic training to educate and assist untrained contributors' skill development for the project in question. For example, Project FeederWatch (bird counting project) provides participants with a handbook, calendar, instructions, and posters of common feeder birds to assist with identification, and Solar Stormwatch provides beginners with a practice game to help them learn how to properly identify and record solar storms, and use the project's online interface.

Examples:
Project Feederwatch - counting birds.
FrogWatch - listening for frog/toad calls and identifying the species for local biodiversity counts.

Gaming/Puzzles

Some citizen-science projects use puzzles, computer game platforms, or Alternate Reality Games (ARGs) to solve complex problems where human intuition or behaviour adds an important ingredient to the problem-solving process or is the subject of study.

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[42] "About the Snowtweets Project." *Snowtweets Visualization*. Department of Geography and Environmental Management, University of Waterloo, 2011. Web. 17 Jan. 2017.
[43] Gibbs, James P., Matthew F. Buff, and Elizabeth Hunter. "Squirrel Mapper." *SquirrelMapper: Home*. SUNY-ESF / National Science Foundation, 2009. Web. 16 Apr. 2017.
[44] Stahlschmidt, Zach. "Backyard ANTology." *Backyard ANTology*. Department of Biological Sciences, University of the Pacific. Web.

Examples:
Foldit - folding protein structures to help scientist understand protein configurations.
Project Implicit - psychological research on processes outside conscious control.

Scientist-Led Educational Programming and Events

Some citizen-science projects are activities conducted in part as informal learning opportunities for volunteers. Often they are sponsored/partnered with agencies or institutions that have public outreach or educational programming. For example, children on a school field trip may sift sand at an archeological site, under the supervision and guidance of a qualified archeologist. Another common type is what Andrea Wiggins and Kevin Crowston refer to as a *bioblast* or *bioblitz*[45] which is a communal, scientist-led ecology or biodiversity event such as an organism census within a designated area.

Similar to the Audubon Christmas Bird Count, bioblitz projects tend to require limited training or specialized equipment and some professional oversight. For example, the Nature Conservancy conducts the annual Delaware Bay Horseshoe Crab Spawning Survey that uses volunteers to count and tag horseshoe crabs on 25 different beaches in New Jersey and Delaware during the spawning season.[46]

Example:
Whatcom Country Amphibian Egg Mass Survey - volunteers attend a six-hour training session and then take part in scheduled group forays to find, identify, and count amphibian egg masses.

Innovation Challenges

Innovation challenges are technology competitions open to the public for which there is usually a cash reward if the goal of the contest is achieved. The barriers to entry are often high as competitors must have their own research and development funding.

Example:
NASA Centenntial Challenge - competition for inventors to contribute to space robotics or other scientific research related to space exploration.

1.4 Motivational Drivers in Citizen Science

There has been a wide range of studies on the non-financial drivers for citizen scientist to volunteer and participate in projects.[47] Volunteers exert effort and give up their personal time without financial compensation and researchers leverage this human capital to fulfill labour demands that would otherwise be untenably expensive at such a scale. Many people are completing a lot work with no expectation of compensation. Understanding what draws volunteers to participate is key to maintaining interest level and ongoing engagement.

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[45] Wiggins, Andrea, and Kevin Crowston. "Developing a Conceptual Model of Virtual Organizations for Citizen Science." *International Journal of Organizational Design and Engineering* 2nd ser. 1.1 (2010): 148-62. Web. 10 p.3
[46] Zito-Livingston, Adrianna. "For Horseshoe Crabs and Red Knots Citizens Science Counts | The Nature Conservancy." *Nature Conservancy*. N.p., 19 June 2017. Web. 10 July 2017.
[47] Roy, H.E., Pocock, M.J.O., Preston, C.D., Roy, D.B., Savage, J., Tweddle, J.C. & Robinson, L.D. *Understanding Citizen Science & Environmental Monitoring.* Final Report on Behalf of UK-EOF. NERC Centre for Ecology & Hydrology and Natural History Museum. 2012. p. 11

A 2013 survey[48] of Galaxy Zoo participants demonstrated that almost 40% of participants' key motivation to take part in the project was the desire to contribute to scientific research. The secondary driver was an interest in the project's subject matter (astronomy). Similarly, a survey of Stardust@home, which is a similar astronomy project involving image classification, found the primary motivation to be a strong interest in the subject matter and program goals.[49]

Looking at ecology and biodiversity projects, studies have noted similar key drivers heavily weighted toward personal interest in the subject matter.

Unlike many of the image-classification astronomy projects, which are largely carried out on virtual platforms, citizen scientists involved in environmental projects are also motivated by their enjoyment of nature and wilderness as many tasks they complete encourage participants to be out in the field (sometimes literally) in order to record observations. The citizen science provides an excuse and opportunity to engage in activities they already enjoy, such as hiking or nature photography, while learning more about the environment.

In Dana Rotman et al.'s study *Motivations Affecting Initial and Long-Term Participation in Citizen-science projects in Three Countries,* their findings on *initial interest* note: "As the data unfolded, it became apparent that participation was highly dependent on personal interest, but there was also a gap between intent and actual participation. While most interviewees expressed a favorable attitude toward citizen science, they did not participate unless a project had a personal value or benefit for them."[50] In particular, Rotman quoted a volunteer: “I think personal interest comes first. Personal interest and personal gain, with information.” [51]

So while there is no financial reward for contributing, volunteers are attracted to a particular project because they do feel they will be at least partially compensated by information and knowledge that allows them to expand their involvement in existing personal interests or hobbies, or bridge an important knowledge gap. They find value in the expertise they can accumulate from citizen-science projects that may even be tangential to the main focus of their personal interest or need (e.g., interests such as photography, hunting, or a need to understand wildlife for pest control purposes).

Interestingly, although public participation in ecological research has a strong history of links to social-change movements and community activism, Rotman et al.'s findings in their study of three countries indicated that project ideology and social-responsibility benefits were *not* key determinants for participants' initial interest in joining a citizen-science project, except in Costa Rica where there is a cultural bias favouring social responsibility with respect to natural resources that is nurtured by education policies and systems[52].

Initial, first-step motivators may be self-centered ("personal interest and personal gain"), but motivations evolve and change over time, particularly as citizen scientists' ambitions become more aligned with the project goals and the participant community's ideology. The study

[48] Raddick, M. J., Bracey, G., Gay, P. L., Lintott, C. J., Cardamone, C., Murray, P. and Vandenberg, J. Galaxy Zoo: Motivations of citizen scientists. *Astronomy Education Review*. In Press. 2013.
[49] Roy, H.E., Pocock, et al. p. 16
[50] Rotman, D., Hammock, J., Preece, J., Hansen, D., Boston, C., Bowser, A., & He, Y. (2014). Motivations Affecting Initial and Long-Term Participation in Citizen-science projects in Three Countries. In *iConference 2014 Proceedings* (p. 110–124).
[51] Rotman, D., Preece, J., Hammock, J., Procita, K., Hansen, D., Parr, C., Lewis, D. and Jacobs, D. (2012). Dynamic changes in motivation in collaborative citizen-science projects. *Proceedings of CSCW 2012*, ACM Press, 217-226.
[52] Rotman, D., Hammock, J., Preece, J., Hansen, D., Boston, C., Bowser, A., & He, Y. (2014). Motivations Affecting Initial and Long-Term Participation in Citizen-science projects in Three Countries. In iConference 2014 Proceedings (p. 115)

demonstrated that with longer-term participation many citizen scientists developed a greater appreciation for the role of their contributions in effecting change. Contributions are not only valuable to scientific research, but are also important factors in conservation-related community outreach and education, habitat preservation, and species-protection efforts. Social responsibility *became* an important motivator for longer-term participation.

Using an online survey featuring Likert-scale responses followed up by interviews, Rotman et al.'s 2012 research assessed participants' views on motivational drivers for citizen science based on the Four Motives for Community Involvement identified by C. Daniel Batson and Nadia Ahmad, and Jo-Ann Tsang in 2002: *Egoism, Altruism, Collectivism,* and *Principalism*.[53]

MOTIVE	ULTIMATE GOAL	CITIZEN SCIENTIST PERSPECTIVE
Egoism	Increase one's own welfare.	Collaboration with scientists enables me to open my horizons to new ideas and knowledge.
Collectivism	Increase the welfare of a group or collective.	Collaboration between scientists and scientific volunteers is beneficial for the volunteers like me.
Altruism	Increase the welfare of one or more other individuals.	Collaboration between scientists and scientific volunteers is beneficial for scientists.
Principlism	Uphold some moral principle (e.g. justice).	Collaboration with scientists is worthwhile for making scienctific knowledge accessible to the public and outside the scientific community.

Table 2 – Four Motives for Community Involvement, (Adapted from Batson et al., Jan. 2002 and Rotman et al., 2012.)

Batson's model sought to find a framework that would allow community leaders to effectively foster greater community involvement using coordinated appeals to key motivations. A successful approach would balance the strengths and weaknesses of each motive so they compliment each other and fuel community involvement.[54] Like a stock portfolio with a *linear progression* that is occasionally re-balanced to ensure optimal return over time.

Batson's model helps explain some of the factors that encourage and influence volunteering and active involvement in community concerns. While Rotman and her group found this framework to be a good starting point for citizen-science participation, their findings indicate that ultimately the model falls short for collaborative citizen-science projects. Citizen-science tasks can be complex and precise and the iterations of task-work can be spread over long periods of time and through multiple stages (compared to civic community participation—for example a town hall meeting where your presence or vote may be valuable, but doesn't require the same effort or commitment as more sophisticated task-work). Rotman notes that motivations shift over

[53] Batson, C. D., Ahmad, N. and Tsang, J. A. Four motives for community involvement. *Journal of Social Issues*, 58, 3 (2002), p. 434
[54] Batson et al. p. 429

the long course of a scientific project and more importantly are "especially salient at particular intersections of activity and decision making."[55]

Essentially the citizen-science community engagement process is *cyclical* rather than linear. Egoism is the main driver for initial participant interest and intent—to satisfy some potential personal gain. Egoism is also the driver for active collaboration—taking on a project task—where the rewards and benefits include training, attribution, and acknowledgement. It is when a task is complete that the citizen scientist must make a decision on whether or not to continue and take on another task that egosim, collectivism, altruism, and principlism, come it to play.[56]

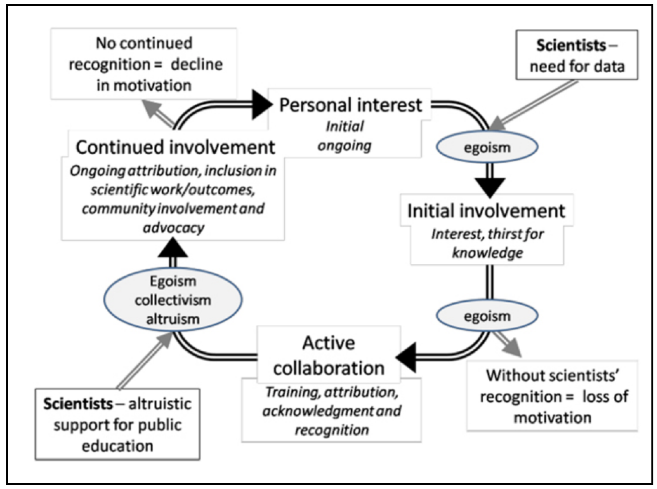

Fig. 5 – A process model of volunteer and scientist involvement in citizen-science projects. (Rotman et al., 2012.)

Considering a task-based approach to participation for the novice/medium, contributory/collaborative levels—and by focusing on participants' motivations only—Rotman's diagram can be greatly simplified. Starting with the basic lifecycle of a volunteer's contribution to an ongoing citizen-science project. Any "unit of work" requested by a scientist of a volunteer will have its own lifecycle. One can break down into four, main, constituent components: *intent, commitment, effort/contribution,* and *renewal*.

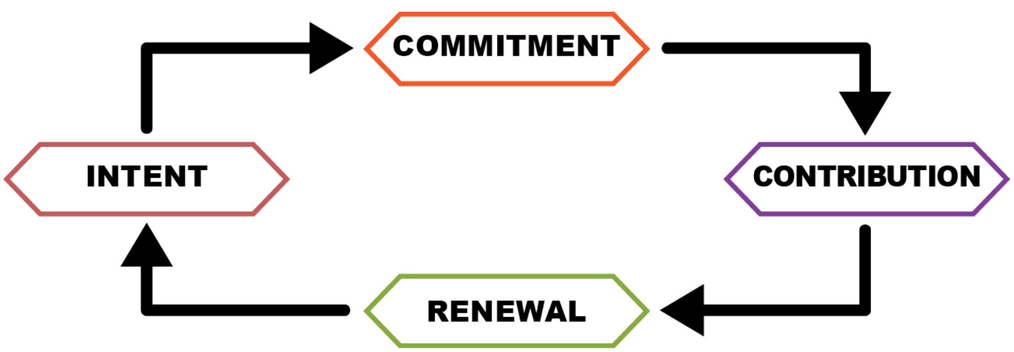

Fig. 6 – Lifecycle components of a volunteer's contribution to a citizen-science project.

For example, consider a citizen-science project such as National Moth Week (NMW), which is a global (not, in fact, "national") biodiversity project similar to—if not modeled directly on—the Audubon Society's Christmas Bird Count. During the last week of July, volunteers are asked to document moth sightings primarily by uploading digital photographs through one of several online platforms partnered with NMW. The project is an annual event and is essentially a moth census.

[55] Rotman, Dana, Jenny Preece, Jen Hammock, Kezee Procita, Derek Hansen, Cynthia Parr, Darcy Lewis, and David Jacobs. "Dynamic Changes in Motivation in Collaborative Citizen-science Projects." *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work - CSCW '12.* 2012: p. 7.

[56] Rotman makes no explicit mention of principlism in her process model diagram, but explained that in interviews principlism was "folded into" related concepts of altruism and collectivism.

To encourage participation and public awareness, NMW suggests hosting “mothing parties” or similar public or private social events, and some organizations (e.g. summer camps) may take advantage of NMW as an informal education opportunity that includes building moth traps, making moth bait, and learning about different local species. That level of participation is not required and individual contributors can take part by simply turning on a porch light and photographing the different species that turn up. Even species identification is optional although the extra effort is helpful and strongly encouraged.

For a singular contributor to NMW the task-based participation lifecycle is as follows: Sign up for NMW, (*intent*), take on a task such as hosting a moth-counting event or photographing moths/recording observations (*commitment*), identify species and upload digital images to a database (*contribution*), then evaluate one’s participation and make the decision whether or not to sign up again the following year (*renewal*).

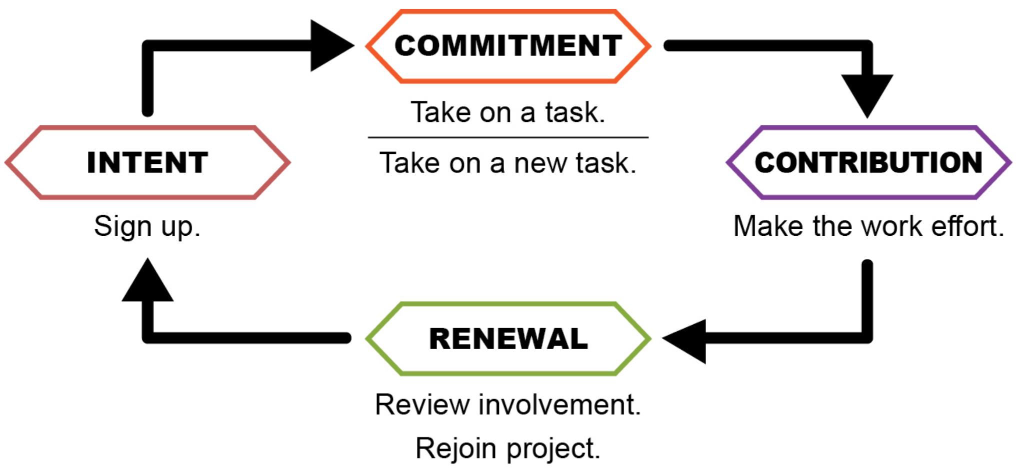

Fig. 7 – Lifecycle activities of a volunteer’s contribution to a citizen-science project.

This general participation lifecycle can be attributed to most environmental/biodiversity projects targeted to novice/medium citizen-science involvement where ongoing volunteer participation is desired. That includes projects that allow the citizen scientist to progress with newly developed skills and move on to more advanced and demanding task-work and not only repetitive programs where the same task is performed each time.

For projects that limit contributions from the public or that request a unique, one-time contribution—such as Darwin’s Dogs[57] which asks for a sample of pet DNA (one sample per dog)—the motivator/task lifecycle still holds true, but “renewal” may take a more subdued form, like advocacy (promoting the project) and recruiting new participants through word of mouth, following up on results and future research, or may entail joining a different but related citizen-science project that supports continued participation, since previous engagement with citizen-science projects influences future participation.

Any transition or junction from one mode of involvement to another is a “salient point” (per Rotman) where volunteer decision-making takes place. At these pivotal points, the motives that drive participation are taken into consideration by the individual contributor. At the most

[57] Saey, Tina Hesman. "Darwin’s Dogs Wants Your Dog’s DNA: Project Seeks to Understand Genes That Govern Canine Behavior." *Science News: Magazine of the Society for Science and the Public* 190.No. 5 (2016): n. pag. 3 Sept. 2016

fundamental level: egoism, collectivism, altruism, and principlism—can be described in more practical terms as questions such as: "What do I get out of this?" "Are other people counting on me?" "Is this actually worthwhile to help research?" The activities, level of involvement, key drivers and base-level motives are all linked within that cycle.

	Intent	⇨ Commitment	⇨ Contribution	⇨ Renewal
ACTIVITY	Join a project.	Take on a task.	Work on the task.	Rejoin. Start a new task.
INVOLVEMENT	Initial contact.	Initial involvement.	Active collaboration.	Continued involvement.
DRIVER	Personal interest.	Interest, thirst for knowledge.	Training attribution, acknowledgement and attributions.	Ongoing attribution, inclusion in scientific work, community involvement and advocacy.
MOTIVE	Egoism.	Egosim.	Egosim + Collectivism.	Egosim + Collectivism + Altruism + Principlism

Table 3 – Linking volunteer's contribution lifecycle to motives for involvement, rewards, and motivational drivers.

For a citizen-science project to successfully retain citizen collaborators, the overall experience of each cycle must be a positive one at each stage of a task-work cycle. At each junction in the cycle, the perceived rewards of participating must be sufficient to satisfy the motives to encourage the volunteer to move forward to the next node.

If they are not sufficient, the cycle is broken. A volunteer may sign up for a project, but never actively start any work. A participant may start a task and abandon the effort, or may contribute the barest minimum to fulfill the task requirement (a single moth photo to NMW, for example). A volunteer who completes the requisite task-work, may do so only one time and never choose to continue.

> *"Intrinsically motivated people engage in an activity because they enjoy the intellectual challenge of a task, because they find it fun, or because it gives them a feeling of accomplishment."*[58]

Common benefits or rewards that influence ongoing participation are linked to the citizen scientists' initial motivations to take part in the project. Learning about the research topic and taking part in the investigative process appeals to personal interest, curiosity, social responsibility, and the desire to contribute and attracts would-be citizen scientists to a given project. Developing skills and acquiring additional knowledge along with recognition from researchers and a developing a sense of belonging to a community of peers have also been shown to be effective rewards for sustained participation.[59]

From the volunteer perspective, the more they contribute, the more they refine their skills and become more adept at fulfilling assignments. The quality of their contributions improves and their investment in project outcomes grows. Their social roles may evolve as they collaborate with peers and assist newcomers, and they may engage in external, self-directed research that further expands their competencies in their area of interest. For example, one "moth-er"

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[58] Franzoni, Chiara and Henry Sauermann. "Crowd Science: The Organization of Scientific Research in Open Collaborative Projects." Research Policy 43.1 (2014): 1-20. *ScienceDirect*. Elsevier, Feb. 2014. p.12

[59] Jennett, Charlene, Dr. "Motivations and Engagement in Citizen Science." Web log post. *Extreme Citizen Science Blog*. University College London, 15 Sept. 2013. p. 2, Web.

contributing to National Moth Week has contributed 1,021 research-grade observations and is better able to assist frustrated newcomers who are struggling to identify species. The newcomers benefit from peer guidance, and the experienced contributor is rewarded with earned recognition, esteem as a member of the project's community, and a growing sense of accomplishment.

Disincentives for continued involvement include frustration with a task or its complexity, a lack of confidence in the ability to perform a given task correctly (concerns about data-quality), and time commitments required by the project conflicting with other priorities in contributors' lives. Access to communication platforms that allow or facilitate useful, positive feedback, peer guidance, and social interactivity is critical to success.

As Rotman points out, citizen-science projects can be long and complex and move through different stages and require different levels of effort and commitment from citizen scientists. Developing a system of interventions or interactions at critical junction points in the task-participation lifecycle could help influence individual citizen scientists to maintain/renew their engagements, strengthen community bonds among contributors, mitigate common barriers to participation, and reinforce their commitment to longer-term projects.

Behaviours and Drivers Related to Games, Hobbies, Collections, Journals and Diaries

For future research considerations, it may be worthwhile to compare the social and psychological factors related to leisure activities that are comparable to participating in research challenges and group problem-solving. Such a study could provide additional insight into the psychological motives that drive participatory endeavors, including citizen science.

In studies of citizen science that use gaming or gaming elements (such as point systems and leaderboards) recognition, evidence of progress, competition, and the interactivity of team-play and community association have been noted as factors that contribute to sustained participation.[60] Many of the same factors can be linked to the appeal of other leisure pass-times such as collecting (e.g. coins or stamps), self-tracking (e.g. counting calories, using fitness trackers), following competitive sports (as a participant or fan) and keeping diaries or journals.

Human nature to count, organize, and classify are appealing to primitive resource-gathering instincts—leading to the urge to accumulate and track items of value, whether real or intangible. For example once calendars were standardized, clocks became common, and industry introduced the concepts of quotas and hourly wages, personal time itself became valuable setting the groundwork of personal accountancy—"How did I *spend* my time?" —leading to hobbies and games to make productive use of leisure time as well as journals, personal diaries to account for "time well spent."

Young quotes University of British Columbia diary scholar, Laurie McNeill:

> *"Once we became able to record time, we became interested in how we were using it. . . Once you have a self and a life that should be lived valuably, you need to account for it."*[61]

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[60] Iacovides, Ioanna, Charlene Jennett, Cassandra Cornish-Trestrail, and Anna L. Cox. "Do Games Attract or Sustain Engagement in Citizen Science?" *CHI '13 Extended Abstracts on Human Factors in Computing Systems on - CHI EA '13* (2013): p. 6 Web.

[61] Young, Nora. *The Virtual Self: How Our Digital Lives Are Altering the World around Us*. Toronto, Ont.: McClelland & Stewart, 2012. Print. p.40.

The personal rewards and motivators of these types of leisure activities can be compared to those that drive participation in citizen science. Most modern studies into the drivers of collection are still focussed on (potentially outdated) Freudian theories and a focus on pathologies such as hoarding behaviour, whereas benign, hobby-based collections are much more common and many of the motivational drivers are very similar to those reported in studies of citizen science participation.

For example, American author, businessman professional rare coin dealer, James L. Halperin, wrote a three-part blog series for the magazine, *The Intelligent Collector*, for Heritage Auction House and included a list of common reasons that people collect things:[62]

Collection: Common Reasons People Collect Things	**Citizen Science: Common Reasons for Participation**
• Knowledge and learning • Relaxation and stress reduction • Personal pleasure (appreciation of beauty, and pride of ownership) • Social interaction with fellow collectors and others • Competitive challenge • Recognition by fellow collectors and perhaps even non-collectors • Altruism (since many great collections are ultimately donated to museums and learning institutions) • The desire to control, possess and bring order to a small part of the world • Nostalgia and/or a connection to history • Accumulation and diversification of wealth	• Interest in the research topic; learning new information • Ancillary hobbies and leisure activities • Pleasure: enjoying the research task • Belonging to a community of peers; community involvement • Competition and/or personal sense of accomplishment • Recognition, feedback, acknowledgement, and attribution • Altruism and social responsibility; sharing the same goals and values as the project • Self-efficacy: affecting scientific work, belonging to the scientific community • Reputation building, social advancement, training, empowerment

This suggests further comparative studies of the psychology behind non-pathological collection behaviour, self-tracking/self-monitoring, and hobbies (which may include participation in citizen science) may provide more insight into participation drivers that bolster or hinder productivity.

[62] Halperin, James L. "Why Do We Collect Things - The Intelligent Collector." *The Intelligent Collector*. Heritage Auctions, n.d. Web. 21 Apr. 2017.

2. OVERVIEW OF THE HISTORY OF PARTICIPATORY CULTURE

Participatory culture is the term referring to the cultural shift from a purely consumptive use of media content, products, and services to one in which the lines between consumer and producer are blurred. The term has its early roots in art and publishing—where media consumers share the responsibility of generating and publishing new content—but also now includes many endeavors where the participation is open to anyone (e.g. how Uber and Airbnb have disrupted traditional producer-consumer relationships of taxi companies and the hotel industry.)

While it is often strongly associated with social media and online sharing culture, it pre-dates digital technology. However, digital technology facilitates collaboration and lowers the barriers to entry. As a result, the widespread adoption of digital communication tools has had the effect of stimulating collaborative projects and peer-production.

2.1 Collaboration and Sharing Pre-Web 2.0: Foundations of Convergence Culture

Comedians make jokes about the sharing of trivial metrics on social media platforms. When Saturday Night Live producers invited Betty White to host the show in response to a Facebook petition to get her on the show, she said in her opening monologue: "...I didn't know what Facebook was. And now that I do know what it is, I have to say, it sounds like a *huge* waste of time."[63]

By the end of 2016, Facebook had 1.86 billion active monthly users[64] and over 1.25 billion represent mobile users.[65] Other online sharing services such as a photo-sharing platform, Instagram, and micro-blogging site, Twitter, boast roughly 400 million users each. YouTube reports having over a billion users—"almost one-third of all people on the Internet."[66] The widespread adoption of digital forums for users to connect, collaborate, modify and share creative projects, or engage in activism or journalistic activities, research and document the world around them is perceived as "radical and new" phenomenon. Due to the accessibility, ubiquitousness, and rapid acceptance of digital sharing platforms, it *seems* that a new set human behaviours came into being along with the emergent technology, however participatory culture, guerilla journalism, data collection and distributed research significantly pre-date digital networks and have been a part of human culture for much longer.

In her book, *The Virtual Self*, CBC Radio One host Nora Young examines the history of self-tracking—logging our activities, experiences, opinions, or personal metrics. While platforms and tools such as Facebook and Fitbit are novel tools, this type of documentation is not a new pass time. Although the data we can capture with modern technology is much, much more vast, and we have the ability to share, compare, analyze, and re-contextualize the information we collect with others in real time far beyond anything that could be done previously.

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63 "Episode 21: Betty White/Jay-Z." *Saturday Night Live*. NBC. New York, New York, 8 May 2010. Television.
64 Fiegerman, Seth. "Facebook Is Closing in on 2 Billion Users." *CNN Money*. Cable News Network, 1 Feb. 2017. Web.
65 Protalinski, Emil. "Facebook Passes 1.44B Monthly Active Users and 1.25B Mobile Users; 65% Are Now Daily Users." *VentureBeat*. N.p., 22 Apr. 2015. Web. 08 Jan. 2017.
66 *YouTube*. YouTube, n.d. Web. 08 Feb. 2017. <http://www.youtube.com/yt/about/press/>.

Similarly, in his essay "What Happened Before YouTube," Henry Jenkins argues that existing, pre-digital, participatory communities actually facilitated the acceptance and rapid adoption of Web 2.0 technologies. He acknowledges that Internet-based platforms have accelerated the expansive growth of collaborative culture, but that do-it-yourself media producers, community groups, amateur scientists (such as those discussed at the start of this paper), grassroots movements and activist networks already existed—linked by pen and ink, telephone and fax networks, and group meetings—and were quick to latch on to new technology that promised to revolutionize their operating procedures.

While Nora Young's book dealt most specifically with how and why people track their own, personal metrics and observations, her book goes into the history of logbooks and journals, and how they were publicly shared. The notion of a private, "dear-diary," secret, first-person confessional is actually a relatively modern concept with roots in the mid-19th century.[67] Prior to that, personal journals chronicling noteworthy milestones, accomplishments, and occasions were conceptually much closer to a real-world, public, scrapbook version of Facebook. She also discusses the evolution of record-keeping and data-recording as these processes evolved through trade, commerce, and science—early accounting ledgers held by merchants for basic book-keeping, maritime ship logs, agricultural (predictive) almanacs, and many of the activities identified in the previous section of this paper that are related to early forms of citizen science (including astronomical charts, birdwatchers' logbooks, bug collectors' observations etc.)—and the public or shared nature of these documents.

Jenkins examines the more organized (if very loosely), do-it-yourself creative community networks: home-video producers, underground comics and zines, alternative newspapers and independent radio. In the years leading up to the widespread adoption of the Internet, there were already social infrastructures, sharing communities, and audiences established during the latter decades of the 19th century from amateur publishing initiatives and early 20th century science fiction fan efforts—plus varying forms of adventure/detective comics, and other pulp serials inspired by the "penny dreadfuls" of the early Victorian era. By the late 20th century amateur publishing activities increased in scope and momentum to include literature and art of the political and counterculture movements of the 1960s, '70s, and '80s that included "video activism", punk rock and the independent music scene, and guerilla journalism—movements that Fred Turner considers the bedrock of modern cyberculture.[68]

These community networks, data tracking/citizen science, interest-based affiliations, and creative cultures—along with their structures, hierarchies, and languages/jargon—were not fundamentally created by online-community applications. Instead, these existing networks quickly leveraged the new, digital-tool offerings to facilitate their activities, to expand their reach and growth, and to beneficially decentralize their membership and functions. However, social-sharing models and collaborative-community structures were available templates for the early, interactive—if then primarily text-based—online communication hubs such as chat rooms, message boards, and online multi-user, real-time virtual game worlds such as MUDs ("multi-user dungeon" games inspired by tabletop, role-playing games like *Dungeons & Dragons*).

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[67] Young, Nora. *The Virtual Self: How Our Digital Lives Are Altering the World around Us*. Toronto, Ont.: McClelland & Stewart, 2012. Print. p.41

[68] Turner, Fred. *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism.* Chicago, Ill: U of Chicago, 2008. eBook.

2.2 Fundamentals of Modern Participatory Culture

Subsequently, more powerful new media technologies quickly emerged with Web 2.0 technology that focused more heavily on user-generated content and provided unprecedented tools to capture, save, review, recirculate, revise, transform, and re-deploy media content. These tools and their accessibility transformed creative/cultural production and distribution by radically changing the relationship between authors and consumers. They vastly increased the potential for *active* participation in the information economy, rather than passive reception (e.g. television watching), and created environments where social rewards encourage active engagement. In *Confronting the Challenges of Participatory Culture*, Henry Jenkins noted:

> *"These knowledge communities change the very nature of media consumption—a shift from the personalized media that was central to the idea of the digital revolution toward socialized or communalized media that is central to the culture of media convergence."*[69]

In *Confronting the Challenges of Participatory Culture: Media Education for the 21st Century,* Henry Jenkins et al. identified five key components of participatory culture:[70]

- There must be relatively low barriers to artistic expression and civic engagement
- Creating and being able to share one's creations with others must be supported
- There must be some form of mentorship where novices can rely on experienced members for guidance
- Participants must feel their contributions matter and/or have value
- Participants must feel a social connection to their peers

Jenkins further asserts that while the participatory culture encourages contribution, it is not mandatory. However, all participatory media consumers understand that they are taking part in a dynamic environment where they may contribute freely at any time. Contributions usually fall into to one or more of the following types:[71]

- **Creative expression:** original and/or derivative works such as fan fiction, fan videos, re-edits, mash-ups, and re-mixes.
- **Social expression:** developing interest-based affiliations or community memberships through media channels such as message boards, social networking platforms like Facebook, Instagram, and Twitter.
- **Distribution and circulation:** developing and influencing media channels and disseminating culture and information (e.g. video streams, podcasts, and blogs) that can be shared and re-shared.
- **Collaborative problem-solving:** developing affiliations to collectively approach tasks and challenges including puzzle-solving, gaming, and contributing to collective intelligence projects like Wikipedia.

Much of the current research devoted to participatory culture refers to 21st century, networked communities that are sharing and collaborating through information and communication technology (ICT). Participants can take advantage of diverse organizational frameworks to

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[69] Jenkins, Henry. Confronting the Challenges of Participatory Culture: Media Education for the 21st Century. Cambridge, MA: MIT, 2009. eBook.

[70] Jenkins, Henry. *Confronting the Challenges of Participatory Culture: Media Education for the 21st Century*. Cambridge, MA: MIT, 2009. eBook. pp.6-7.

[71] Jenkins, Henry. Confronting the Challenges of Participatory Culture: Media Education for the 21st Century. Cambridge, MA: MIT, 2009. eBook. p.9.

creatively appropriate content, generate new content, receive feedback, and give feedback to others in experimental, virtual environments. This provides opportunities for informal learning, discovery, socialization, and cognitive development through community involvement—even where dominant interests seem frivolous—by requiring contributors to develop key competencies (technical skills, critical thinking, research skills, interpretive abilities, successful collaboration) in order to successfully navigate their virtual environments and contribute effectively if they so choose.

Online participatory culture boosts the capacity for collective intelligence projects as it facilitates knowledge pools and teamwork for creative problem-solving and research—whether that collaboration comes in the form of citizen science, activism, multi-player role-playing games, or the crowdsourced development of a detailed episode guide for a television series or a concordance to a movie franchise. As Jenkins affirms, a significant portion of participatory culture endeavors are devoted to recreational pursuits related to popular culture.

For example, he devotes the first chapter of his book, *Convergence Culture*, to the phenomenon of the successful reality-television show *Survivor* and the extraordinary effort that fans put into the collective goal of spoiling the season: uncovering who was the season winner before the series concluded. Other contemporary examples would be fan-based detective work in response to T*he Walking Dead* season finale cliffhanger trying to determine which character was killed, and *Memory Alpha*: an online, open-source, *Star Trek* encyclopedia started in 2003 containing over 42,600 entries.

To be clear, while a large portion of participatory culture endeavors revolve around pop-culture leisure pursuits, valuable scientific, educational, civic and sociopolitical undertakings have also been strengthened by the opportunities offered from networked, contributory activities. While entertainment fans were creating *Memory Alph*a in 2003, that same year Troy Bartlett launched *BugGuide,* an online community where users can learn about North American insects and contribute data, and long-standing, citizen-science projects have moved forward on digital platforms that enable broader participation. Non-frivolous goals are being met.

Affinity Spaces: How Citizen Science Resides in the Spectrum of Participatory Culture

In the virtual realm of online participatory culture, a citizen-science project can be considered a type of *affinity space*—a place (either physical or virtual) where people are attracted by a shared interest and common goal or activity and where informal learning is a result (whether or not that was an intended goal). According to linguistics expert, James Paul Gee, affinity spaces are organized around a common endeavor and/or interest and are not dependent on the cultural background of participants (for example, they are not based on race, social class, age or gender). The virtual spaces are shared by participants whose abilities and experience range broadly from neophyte to expert and knowledge-sharing occurs across the full participant spectrum.[72]

Citizen-science participation is consistent with Gee's description of an affinity space—participants are drawn by a mutual interest in the subject mater and willingness to contribute to the common endeavor. Affinity-driven interactions, content generation, and social learning are inherent components of citizen-science projects.

[72] Gee, James Paul. *Situated Language and Learning A Critique of Traditional Schooling*. New York: Taylor and Francis, 2004. Print. pp. 70-82.

However, it is important to note that digital, participatory culture and virtual, affinity spaces are not conventionally organized by social or economic hierarchies. Motivators for participation are not financial, but follow a "gift-economy structure" where relationship-forming exchanges occur that are based on a duty to give, receive and reciprocate and for which the incentives are recognition and esteem.[73] Plus, affinity spaces typically have porous leadership structures where the “leaders” function as facilitators and there is no obvious boss-worker relationship.[74]

Where modern, ICT-mediated citizen science may diverge from typical expectations (that come from participants' exposure to other popular affinity spaces) will be in the organizational control and leadership structures. This is particularly true for novice/medium participants at the contributory and non-expert collaborative levels—the laypeople—whose activities are directed and controlled by the scientists and researchers at the top (as discussed in Section 1.2 of this paper).

Participants more familiar to those non-hierarchical, self-organizing, online community models—such as those associated with pop-culture discussion forums and video games—may be more accustomed to more democratic, collaborative models and they may have expectations that are inconsistent with a more formal chain of command (such as the scientist-volunteer relationship). In virtual communities, such as online forums, volunteer moderators or platform hosts may ensure participants adhere to forum rules and community standards of behaviour (e.g. "Don't be a jerk."), but overall participation may feel less restrictive than in a top-down, citizen-science environment that where leaders control the science project or experiment to ensure specific outcomes are achieved.

For example, a biodiversity project hosted by the David Suzuki Foundation is more likely to have a more formal organizational structure and behaviour guidelines than a Reddit thread that's trying to spoil *The Walking Dead*. Additionally, a citizen-science project may be rigidly structured in a way that does not allow for modification or may have limited routes to participation.

Where possible, it would benefit citizen-science projects to ensure they meet the essential elements that are expected from an online community and affinity space:

- **Low barriers to artistic expression/civic engagement:** Citizen-science projects and the tools that allow individuals to take part should be readily accessible, and task complexity appropriate to the expected level of participation (novice/expert).
- **Creating and sharing creations must be supported**: Citizen-science projects should be interactive and dynamic. Involvement and collaboration should allow for some autonomy (self-directed work) and independent decision-making and creativity.
- **Mentorship and guidance:** Citizen-science projects need to provide training and opportunities to develop skills, learn more about the topic, and provide tips to improve the quality of submissions.
- **Participants must feel their contributions have value**: Citizen science should provide recognition from peers, acknowledgement from researchers, and inclusion in ongoing research.
- **Participants must feel a social connection**: Citizen-science communities are likely to have social bonds based on a common interest in the subject matter, the projects should provide opportunities for discussion, questions, and community involvement.

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[73] Jenkins, Henry. "What Happened Before YouTube." *YouTube: Online Video and Participatory Culture*. Ed. Burgess, Jean. Malden, MA: John Wiley and Sons Ltd: 2012. Print. p. 120

[74] Gee, James Paul. *Situated Language and Learning A Critique of Traditional Schooling*. New York: Taylor and Francis, 2004. Print. p. 79.

Understanding the Digital Participation Gap and Its Consequences

Modern participatory culture is typically linked to the era of media convergence and ICT-mediated activities. Many citizen-science projects now rely heavily on digital platforms for community involvement even if the nature of the projects—particularly in the environmental biodiversity fields—primarily relies non–ICT-mediated activities such as fieldwork (collecting water samples, measuring snow depth, recording sounds). With the proliferation of Internet enabled personal devices and related communication tools, many (if not most) citizen-science projects rely on digital communication as the primary means of coordinating citizen-science activities and data collection.

This means there is a risk that inequality in access to technology and exposure to digital culture can affect "digital fluency" and limit the potential for participation. For example, Canadian Northern and remote communities may face barriers to participation if it relies on connectivity, affordable broadband technologies, and familiarity with digital environments and digital culture.

Although public participation in scientific research pre-dates the existence of the Internet and has been very effective prior to online networking (as we have seen with the grassroots citizen-science activities during the AIDS crisis in the 1980s), in the post-convergence era the efficiency digital technology offers has led to more citizen-science communication functions being conducted primarily online. Technology access will continue to be a barrier to many collaborative activities, which will affect citizen-science projects that have significant virtual components.

This could impact environmental citizen-science studies in areas (remote or economically stressed) where accurate and regular data collection/reporting would be beneficial for policy development related to areas such as: public health, climate change, air quality, water and wastewater management, and more.

2.3 Transmedia Communication: Digital Fluency and Participation

> *"Participatory culture shifts the focus of literacy from individual expression to community involvement. The new literacies almost all involve social skills developed through collaboration and net- working. These skills build on the foundation of traditional literacy and research, technical, and critical-analysis skills learned in the classroom."*[75]

Digital literacy in the age of ICT-mediated participatory culture requires more than the ability to read and proficiency with devices. Being digitally fluent requires a comprehensive knowledge of social, cultural, and economic ideologies that influence content creation, access, and distribution. One needs to be able to communicate with an awareness of contextual values and relationships. For example, a person will behave differently with friends and family on Facebook, than on LinkedIn where there is an expectation of business professionalism.

As a concept, digital literacy builds not only on traditional print and visual literacy (interpreting actions, objects and symbols—including text), and computer literacy (the knowledge of using devices), but also on the competencies related to networking, critical thinking, and social

[75] Jenkins, Henry. Confronting the Challenges of Participatory Culture: Media Education for the 21st Century. Cambridge, MA: MIT, 2009. eBook. p. xiii

protocols and behavioural standards (“netiquette”)—and how to manage these components across a variety of media platforms. Two key components of digital literacy that are reflected prominently in citizen science include:

Communication, collaboration, and civic engagement
The ability to communicate with others using online tools and virtual platforms and interact constructively, responsibly, and ethically—while meeting social, institutional and cultural expectations of a given community hosted on a given media platform.

Networking, information management, and content creation
The ability to locate and *use* online resources effectively—navigating resources in ever-changing media configurations to search, sort and synthesize information. It is not enough to be familiar with where to find information, one has to be able to prioritize and evaluate content quality and make connections to integrate information coherently. A less skilled individual will use digital tools to copy information (e.g., a student copy-pasting and creating a plagiarized term paper), an adept individual will be able to assimilate information from disparate sources to support and develop their own original ideas and create something new. For example, a researcher may note analogies between deep sea diving and space exploration, and then develop an original concept for breathing apparatus.

Information Management	Locating, capturing, saving, evaluating, prioritizing, and organizing content coherently and efficiently.
Collaboration	Being able to collectively approach a task and contribute to creative content or problem-solving.
Communication and sharing	Networking, sharing and communicating effectively using onine tools and virtual platforms.
Content creation/transformation	Ability to integegrate, revise, re-elaborate, transform and re-deploy media content and create original work.
Ethics and Responsibility	Using digital platforms constructively, responsibly, and ethically according to community norms and values.
Technical Operations	Using technology, media, and digital tools effectively, solving problems with digital technology.

Table 4 – Digital competencies. Adapted from Anusca Ferrari’s *Digital Competence in Practice: An Analysis of Frameworks*. p. 6.

Transmedia Navigation and the Multimodal Approach to Content Consumption

An important aspect of the networking and information management aspects of digital literacy is the ability to “think across media”[76] (thinking multimodally)—the ability to not only recognize the same content in different media formats (modes), but also to follow ideas, trains of thought, and context that is carried from one mode to the next, and being able to express oneself effectively through various modes communication. For example, one can recognize Batman in various incarnations from comics, television series, live action film, animated series, and from actors

[76] Jenkins, Henry. *Confronting the Challenges of Participatory Culture: Media Education for the 21st Century*. Cambridge, MA: MIT, 2009. eBook. P. 89

Adam West to Christian Bale, but a greater intellectual investment is required for determining if they share continuity in a common narrative universe.

Additionally, media convergence has resulted in the ability to customize media consumption at unprecedented levels. With global networking and wireless communication technologies, communication and media consumption has become dynamic, portable, and multimodal—a media consumer can watch a short, documentary film on crow species that is embedded on a website in a YouTube video, access an online field guide for birds on a website, photograph a bird with a smartphone, and upload the image to a citizen-science portal while travelling on a Greyhound bus.

Traditional print and broadcast media content was disseminated uni-directionally—from author to reader, radio station to listener, or filmmaker to audience. The multimodal approach to content consumption means content consumers are no longer uniquely relying on a single portal to access information or creative content, but may be approaching content obliquely depending on the path that led them to it. For example, they may arrive to a media portal as a result of exploring hypertextual links within a primary document that they are consuming (whether it is text, film, or other digital content).[77]

As previously stated, a key feature of participatory culture that has been strengthened by media convergence, is the ability to capture, modify, and re-deploy media content. This represents a major shift in the author-audience relationship particularly with respect to audience participation. Media consumers are no longer satisfied to be passive spectators, but are seeking audience empowerment: the ability to effect change and influence outcomes.

This is beneficial to both creative communities as well as citizen science because it means that media consumers are actively seeking out opportunities for involvement. Looking at the precedents set by entertainment franchises, media consumers have been able to insert themselves into content-development processes through web platforms, gaming, exploring transmedia narratives and creating their own ancillary content. Discussing his film and the seminal transmedia project that accompanied it, *The Blair Witch Project* co-director, Eduardo Sanchez observed: "What we learned from Blair Witch is that if you give people enough stuff to explore, they will explore. . . If people have to work for something, they devote more time to it. And they give it more emotional value."[78]

The Blair Witch Project had cultivated a dedicated following through a very believable, detailed and provocative website that firmly established a rich history and mythology for the Blair Witch over a year before the film was released. Analogously to the cycle of citizen science—intent, commitment, contribution, renewal—visitors to the Blair Witch website portal were discovering and exploring the fictional, supernatural, mystery scenario (four missing college students), examining clues and evidence, developing theories and sharing them with their peers. Each effort was rewarded by access to more narrative possibilities and discussion forum feedback, and also fed in to emotional links created by the story.

Creating emotional value is integral to the "stickiness" and success of a project. It is here that citizen science can learn important lessons from the arts and entertainment industries where they use narrative to appeal to and connect with the people who are interested in their content.

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[77] Zoll, C. "Documentary and Nonfiction Film in the Age of Media Convergence." IS 304 Essay. University of Waterloo, 2014. Print.
[78] Pratten, Robert. "The Evolution of Storytelling." *Transmedia Storyteller*. YouTube, 03 Sept. 2013. Web. 10 Apr. 2014.

2.4 Importance of Narrative: Learning from Transmedia Documentaries

> *"Stories are one of the first forms of learning that a child encounters in life. Throughout life, stories shape and characterize the ways in which we interact with people, society, and information. Stories are the 'substance of generations, history and culture. They reflect our journey though life. They may prove to be an important research tool.'"*[79]

Narrative takes what would otherwise be a list—who, what, where, when, and how—and creates a relational structure and chronology that helps an audience understand how each of those components relate to one another. The audience can *experience* the information in context, which helps them remember it and mentally organize it into their own practical-knowledge toolkit.

With media convergence and the shift in audience expectations moving toward participatory experience, documentary filmmakers in particular were quick to embrace the opportunities offered by new media for public outreach. Social documentary filmmakers were quick to take advantage of new channels that release some control of the documentary work to their consumers allowing them to be active contributors to the documentaries, rather than just passive consumers.

Traditional, long-form documentary filmmaking has relied on a series of conventions that ultimately built on classical oratory traditions of storytelling—but always taking a one-way path from filmmaker to audience. With the accessibility of new media, documentarists can now interact directly with their audiences and engage in a type of dialogue—the audience experience now includes having the filmmakers talk *with* them not *at* them. Luci Westphal, the director of the transmedia project *All's Well and Fair,* describes the audience development from passive consumer to active consumer-contributor:[80]

> *Time and progress were on my side when technology and culture had developed to the state we're in now and I am able to utilize the video streaming and sharing site YouTube, social media networks and mobile apps like Facebook and Twitter, RSS feed websites like WordPress and interactive platforms like Disqus and Google Hangout to release All's Well and Fair not just like a documentary film, but as an interactive transmedia experience, where everyone can become part of the conversation via comments, discussions and their own response videos.*[81]

In the case of Westphal's documentary project and many others, the audience's use of the web-based channels are not just providing ancillary content. They are integral components of the documentary project with each channel providing a way to explore, analyze, record, and chronicle the subject matter in ways that go beyond what film alone can do. Each platform is an entry point to the project that offers a distinct textual experience for the participant. Each content contribution—online comment, blog entry, Instagram image, video response, or social media post—creates a new entry point to the project (and its subject matter) and stimulates more public response/participation and more interaction the original documentary creators. The project then also becomes a "living document" that may be perpetually updated with new,

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[79] Webster, Leonard, and Patricie Mertova. *Using Narrative Inquiry as a Research Method: An Introduction to Using Critical Event Narrative Analysis in Research on Learning and Teaching*. London: Routledge/Taylor & Francis Group, 2008. p. 25.
[80] Zoll, C. "Documentary and Nonfiction Film in the Age of Media Convergence." IS 304 Essay. University of Waterloo, 2014. Print.
[81] Westphal, Luci. "Transmedia?" *Alls Well and Fair*. N.p., 18 May 2012. Web. 7 Apr. 2014. <http://allswellandfair.com/transmedia/>

relevant data and content as participants interact with it and create their own hypertexts linked to the main project.

Citizen science shares fundamental attributes with documentary projects. At their cores, they are both research-based projects that collect, analyze and interpret information and raw data. Both reside in types of affinity spaces and flourish with increased public participation and involvement with the subject matter. Where they diverge is where one is asking for participation in the form of task-work, often narrow in scope, and the other accepts contributions that may be more expressive and creative in nature such as sharing opinions and stories—narrative contributions. The latter's use of narrative gives it an advantage that is currently under-utilized by citizen science, particularly at the beginner and intermediate levels.

Narrative establishes stronger emotional ties to a project that encourage participation that feels personally meaningful to contributors and helps create social connections that adds value to their interaction. Documentaries elicit emotional responses and opinions (positive or negative) that creates a rapport with the audience, and the audience may feel prompted to respond or contribute. Transmedia documentaries provide channels for the resulting creative and social expression.

This element of personal meaning is often absent from citizen-science projects at the novice level where the primary goals are completing task-work and collecting accurate data. At more advanced levels of citizen-science participation, such as expert/co-creator levels, intermediate collaborative levels, or projects with gaming there may be more room for creative problem solving and teamwork (for example Foldit or the Polymath Project). However, since novice-level projects tend to be heavily weighted towards activities such as observational measurement, recording, data collection, and transcription, researchers may feel there is little need (or desire) for creative expression. Their focus is on accurate and reliable data and they may overlook the value added to contributors' experiences that narrative and creative expression provide.

By adding elements of transmedia storytelling, a citizen-science project can fulfill the expectations of participatory culture without compromising the primary content—the research project—by supporting it with related media experiences that provide additional opportunities for meaningful social expression and creativity. If personal interest in the subject matter is the initial driver for participants to engage with a citizen-science project, then injecting subject-matter narrative content into the experience should help attract and retain participants.

2.5 Models for Linking Media and Developing Points of Entry to a Project

In his book *Transmedia Storytelling*, Max Giovagnoli identifies three transmedia communication models that he labels—supportive, competitive, and omnivorous—that he uses to describe the relationships of the different media platforms to one another and how a story is managed among them.[82]

The **supportive model** uses cross-platform iterations of an existing narrative. It provides audiences with a menu of options for approaching and interacting with the same content. A classic example would be 1982's *E.T. The Extra-Terrestrial,* a family-oriented, blockbuster film. The film novelization was published soon after the theatrical release, so to were illustrated storybooks for children, a phonograph LP record of the story (narrated by Michael Jackson), a

[82] Giovagnoli, Max. *Transmedia Storytelling: Imagery, Shapes and Techniques*. Pittsburgh: ETC, 2011. Print. p. 48.

critically panned video game that attempted to adapt the film for gameplay for the Atari game console, and eventually a home-video release on videocassette. The supportive model provides multiple touch points for consumers to explore the content, but control over the intellectual property and content generation is more rigidly assigned to the original creators.

The **competitive model** uses different versions of the core project content and disseminates them across different platforms to exclusive audiences. Typically, this is employed as a marketing tool that uses the *intervention principle*[83]—priming, referring, and rewarding—to drive interest in a product. For example, attendees of a comic book convention may get to see the first teaser trailer of a feature film weeks before it is generally released (a trailer that *will* be leaked online). Subscribers to a particular mobile phone network may also get exclusive access to another version of the film trailer with different, teasing footage and different clues about the story line. Then the full trailer is released online a few days later on the films official YouTube channel. The teaser viewable on the mobile phone acts as a primer that generates anticipation, it refers the viewer to the movie's website, where the mobile phone subscriber will be rewarded by a more complete overview of the upcoming feature film.

Giovagnoli's **omnivorous model** is one dependent on a central narrative construct from which all other related storylines branch out and relate back. It offers self-contained "expanded universe" narratives that bridge across multiple platforms and each one enriches an overarching story universe. The content overlaps, but is not purely repetitive. One of the most familiar (and vast examples) would be the *Star Wars* universe. Audiences can enjoy the original film experience of the trilogy and prequels independently, but they can explore the narrative envelope to a much greater depth if they also choose to watch the animated television series, *The Clones Wars* (that takes place between the second and third prequel films), read canonical novels based on second-tier or background characters, and play video games set in the *Star Wars* universe that share continuity with the films. The central narrative framework operates almost like a topic of discussion around which the transmedia content revolves. It functions as a *communicative affinity space* that encourages creative and social expression, collaboration, and releases some responsibility for authorship to the consumers.

An example from transmedia documentaries is Elaine McMillion Sheldon's *Hollow: An Interactive Documentary.* The project was originally conceptualized as a linear documentary film about rural America and the devastating effects of a boom-and-bust economy from the perspective of a post-bust, mining town in West Virginia. Realizing the scope of a film was inadequate to contain the rich depth of all the intersecting stories and experiences of the community, McMillon developed an integrated, transmedia project that combined traditional, linear media with web-based social platforms that supported non-linear, community-generated content. It includes film, video portraits, mapping, blogging, micro-blogging, and social media platforms such as Facebook. Visitors are encouraged to explore and contribute to the multimodal project's narrative ecosystem. With continual contributions and updates, the project is forever growing and evolving as a living document perpetually recording and interpreting new information and capturing a wealth of economic, social, and historical data.

The Omnivorous Transmedia Model for Citizen Science Engagement

Like many documentary projects, the omnivorous model of transmedia communication—which is usually web-based—is best suited for and most applicable to citizen science. Most citizen-science projects focus on biological or environmental monitoring and many of those that operate

[83] Giovagnoli, Max. *Transmedia Storytelling: Imagery, Shapes and Techniques*. Pittsburgh: ETC, 2011. Print. p. 43.

at a level suitable for beginners are local, grassroots, DIY initiatives or are chronically underfunded academic inquiries. Key benefits of omnivorous model for beginner-level citizen-science projects are: the affordability of web-based media platforms, the scalability of design options, and the accessibility of the technology platforms (to both citizen science volunteers and the researchers themselves), and the moderate learning curves for implementation on a shoe-string budget.

For a citizen-science project portal, the subject matter should be the center point of discussion around which all other content resides—if we remember that the initial motivator to participate is interest in the subject matter—and the content should reinforce contribution in its call to action. The intent should be to draw users interested in the topic to the main portal with rich content that is useful, has value, and provides a social dimension and enjoyable user experience.

In *Getting Started with Transmedia Storytelling,* Robert Pratten notes there are three stages of audience engagement: discovery, experience, and exploration.[84] A promise of useful, valuable content (such as an answer to "What's that bug?" or "How to I keep the raccoon out of my soffit?") serves as the initial hook of discovery. Narrative content is central to experience. A short, how-to video presents a better story about critter-proofing soffits against raccoons, than an expository set of instructions. If the experience is positive and the viewer's interest is maintained, the content consumer will continue to explore the interwoven media offerings, such as reaching out through accompanying message board forum allows for specific questions to be asked and answered, or to review more content about raccoons.

Fig. 8 – Robert Pratten's three stages of audience engagement.

With transmedia content that revolves around a central theme, the engagement cycle of one medium can serve as the discovery prompt for the next. A how-to video about raccoon proofing can lead to a citizen-science project tracking urban raccoon distribution, which in turn would introduce interested visitors to the citizen science participation cycle call to action. Rich content that rewards visitors with a good story, a good user experience, and good social interaction will encourage repeat visits to the portal. This is particularly true if the content is also dynamic and regularly updated (with either producer- or user-generated content, or a combination of both.) The flow parallels the citizen science experience: the commitment to the project that satisfies the initial interest and thirst for knowledge, a positive experience during the contributory effort, and the rewards of recognition, feedback and social involvement.

[84] Pratten, Robert. *Getting Started with Transmedia Storytelling: A Practical Guide for Beginners*. 2nd ed. N.p.. 2015. p. 137

3. TRANSMEDIA COMMUNICATION FOR BIOLOGICAL-MONITORING, CITIZEN-SCIENCE PROJECTS

3.1 SquirrelMapper: A Case Study of a Citizen-Science Experience

A recent study done by the Earthwatch Institute in the UK in partnership with the Brazilian Academy of Sciences established that most citizen-science projects are in the fields of biodiversity monitoring, biological research, and environmental monitoring. Of the many projects in those areas, 77% are in biological monitoring.[85] For the purpose of this thesis, we will explore an example of a biological monitoring project that operates at a level suitable for novice and medium contributors to see what this project does currently and how it could leverage transmedia communication to theoretically improve its engagement success.

SquirrelMapper is a project by the State University of New York College of Environmental Science and Forestry that is supported in part by the National Science Foundation. The project is studying the hypothesis that the Eastern Grey Squirrel, which used to be solid black in colour, evolved over the past 200 years to include a grey morph in response to changing habitat conditions which required different camouflage. Old growth forests and urban environments have more shadows and black morphs can hide more easily in those environments. Grey morphs are better concealed in new growth forests.

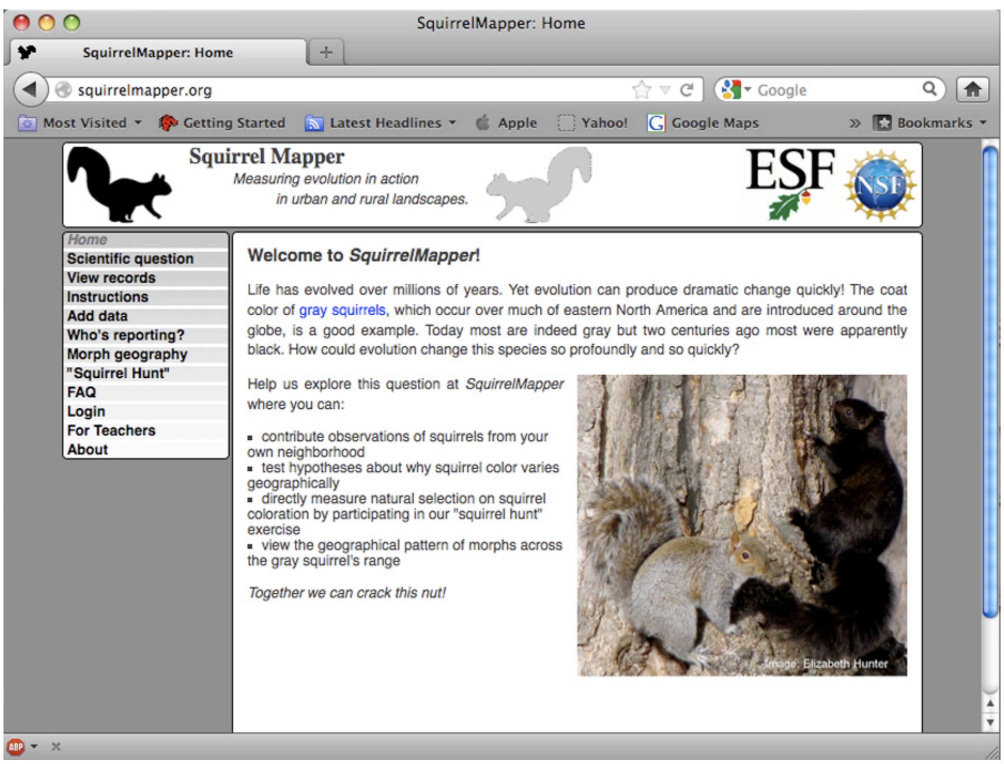

Fig. 9 – SquirrelMapper homepage by New York College of Environmental Science and Forestry

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[85] Cunha, Davi G.F., Jonatas F. Marques, Juliana C. De Resende, Patricia B. De Falco, Chrislaine M. De Souza, and Steven A. Loiselle. "Citizen Science Participation Research in the Environmental Sciences: Key Factors Related to Projects' Success and Longevity." 2017. MS. Annals of the Brazilian Academy of Sciences. Brazilian Academy of Sciences, Sao Carlos. p. 5

The project can be considered representative of a novice-level biological monitoring project because: it features local concerns (project data is world-wide, but the focus on Onondaga County, New York); the project is conservatively funded and must rely on DIY and grassroots approaches (they use basic email and postal mail forms rather than more advanced online databases); the project has low barriers to entry and is suitable for all ages with novice skill levels, it provides materials for teachers in order to provide supplementary, informal learning opportunities for children.

3.2 Evaluating SquirrelMapper's Current Participation Platform

The SquirrelMapper project relies almost exclusively on its website, www.squirrelmapper.org and the skills required to contribute are observation, data recording, and data input. Registered contributors are asked to count black morphs and grey morphs of the Eastern Grey Squirrel. The data required to be input in their online form are: observation date, morph colour (grey, black, albino, white non-albino, other), type of observation (live, road killed, hunter killed, other), number of squirrels, co-ordinates of observation (latitude and longitude), plus there is room for additional observational comments. The site also provides downloadable datasheets that can be used in the field and can be sent by postal mail if participants do not have Internet access.

The site has five pages of expository writing describing the project, how to submit data, a 600-word overview of the genetics behind squirrel morphs, and 370 words of information about squirrels in general. In addition to data submissions, SquirrelMapper also has a simple, online game for registered participants (who must submit a username and email address to register) as part of an interactive experiment.

The game displays a series of 120 photographs of a forest or urban settings with one rectangular, squirrel-coloured swatch superimposed over teach photograph. Users must find and click on the swatch as a counter records the amount of time the user takes to find the "squirrel." The game is to provide further proof for the hypothesis that the Eastern Grey Squirrel developed a lighter coat for camouflage in new-growth forests. The longer the game-player takes to identify the swatch in the image, the better camouflaged the squirrel stand-in.

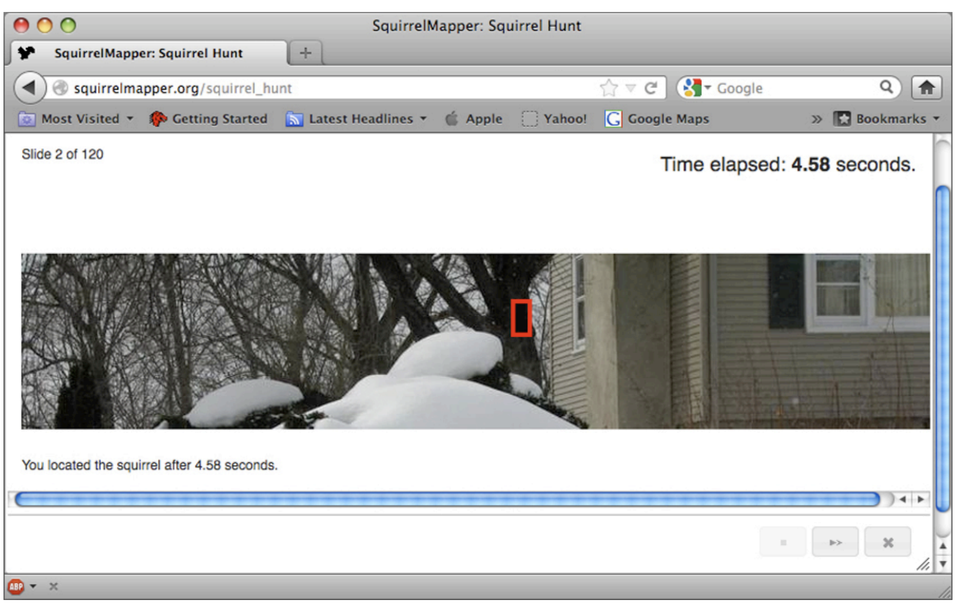

Fig. 10 – A frame from the Squirrel Hunt game from the SquirrelMapper to measure selection pressures on black and grey squirrels in urban and natural environments.

The game is the only interactive element of the SquirrelMapper citizen-science project. It is long, repetitive, and not conducive to repeat gameplay. There is no way to interact with other participants or researchers (the only contact point for the project is webmaster@squirrelmapper.org). A hundred of the most recent entries are posted publicly, but the data is anonymized with no participant or username attribution. A map displays the geographic locations of entries with pie-charts indicating the ratio of black to grey squirrels.

Considering the motivating drivers of citizen scientists and the expectations of online culture, there are deficiencies with the SquirrelMapper platform that are immediately apparent:

- If the initial discovery incentive for a SquirrelMapper website visitor is an interest in the subject matter, the SquirrelMapper site does not contain an abundance of content about squirrels and does not contain a wealth of hypertextual links to related internal or external media content.

- There are no rewards for contributing related to training, acknowledgement or attribution, and there are no social elements to provide mentorship, guidance, or community involvement. Registration and submissions are not acknowledged even in automated email replies.

- From the perspective of convergence culture, the project provides no opportunities for creative expression, developing interest-based affiliations or joining a community, and there is no narrative structure to engage a citizen scientist on an emotional level or that would make the project work meaningful or feel valuable.

Other than the very low barriers to participation and the appeal of outdoor activity, there are few incentives to engage visitors and move them through a process of discovery, experience, and exploration through the portal or motivate them to contribute to the study itself. The structure of the project does not satisfy the motivational drivers for citizen science (Fig. 7) or meet Jenkins' criteria for participatory culture—the project asks for data contributions but its interface is not conducive or inviting for participation or public collaboration.

3.3 Leveraging Transmedia Communication Strategies to Improve Engagement and Foster Collaboration in SquirrelMapper

To draw potential contributors to SquirrelMapper, the citizen-science project needs to appeal to the main initial driver of citizen science: an interest in the subject matter. To fully realize its potential the site needs to offer content that goes beyond the narrow scope of its research in order to offer rich content about its subject matter—the Eastern Grey Squirrel. By positioning itself as a resource portal *as well as* a participatory undertaking, the project will immediately have value to those interested in the topic. Operating from a position of knowledgeable goodwill (offering information before asking for contributions), the SquirrelMapper portal can grow as an affinity space for like-minded individuals who share an interest in squirrels, urban wildlife, nature, or related subjects.

Expanding informative, topical content within the site and linking to curated, high-quality, third-party content could position SquirrelMapper as a credible resource hub. Establishing a social media presence and integrating online social platforms would enable interest-based affiliations and social connections that develop a SquirrelMapper community of participants. This would expand opportunities for peer interaction and mentorship, and would also generate shared user-created media content that could help sustain discovery and advocacy for the project.

As we have seen earlier, recognition, feedback, attribution and community involvement are key drivers for renewing a participant's commitment to a project. This social component cannot be overlooked and be absent from a citizen-science project if participation is to be sustained. Cultivating a community would be the first step in elevating SquirrelMapper's engagement profile.

Infusing Narrative into a Data-Driven Project: Reframing the Question

Adding narrative adds meaning to content. Narrative content also provides a launch point for creative expression—a key element in modern online communication and participation as noted by Henry Jenkins. For data-driven, scientific research projects, the notion of storytelling may seem counterintuitive to researchers who are focused on data collection, analysis, and evidence-based interpretation. However, adding narrative is not only a useful way to convey information, but it is also a valuable engagement tool that offers creative means for soliciting data contributions and fostering continued engagement.

A citizen-science project can successfully tell transmedia stories through journalistic blog posts, simple how-to videos or short-form videos, and question-and-answer sessions on social media platforms or message boards. The content does not need to be extravagant with expensive, high-production value (such as a long-form documentary filmmaking), but the story envelope needs to resonate intellectually and emotionally with media consumers. A more powerful narrative tool would require converting the data-driven narrative content to character-driven content. For example, SquirrelMapper's call to action most simply stated is: "*How many* black and grey squirrels are in your local environment?" Reframing the question to a character-driven request would produce: "*Who* are the squirrels in your neighbourhood?" The question "Who are the squirrels?" opens the door to creative expression without compromising data. The act of identifying and naming individual squirrels—each with unique traits or backstory—is a creative exercise that satisfies the project data requirements and also produces a wealth of additional sub-sets of data such as: gender, behavioural traits, relationships to other specimens, and distinguishing features that may be indicative of disease, injury, or environmental conditions. Such a creative exercise also fuels community discussion by releasing some control of the project's creative content to the audience and encourages sharing and re-circulation of that user-generated content which would also serve as a mechanism for future discovery and advocacy—new entry points for newcomers.

Threading a Long-Form Story through SquirrelMapper

A missed opportunity for a biological monitoring project that focusses on wildlife, like SquirrelMapper, is the ability to feature ready-made characters taken from particular individuals in the specimen pool. The project could focus on an individual, representative specimen as a character or protagonist in an ongoing, real-life story.

For example, Preggers is a pregnant Eastern Grey Squirrel living in an urban environment. A series of short, blog posts, occasional status updates, or video footage styled as "micro-documentaries" that follow a protagonist specimen, like Preggers, would provide an ongoing narrative structure—with multi-media potential. It would serve as a hypertextual, narrative framework that supports the SquirrelMapper project and acts as a creative device through which data, analysis, and scientific information can be conveyed.

For example, Preggers can be used to provide scientific and behavioral information about her species to the members of the affinity-space community by being the impetus for answering questions and disseminating knowledge: How long is the gestation period for squirrels? How many baby squirrels are in a litter? Will Preggers' babies be black or grey or will she have babies of both colours? How long does it take for baby squirrels to be weaned? What is the survival rate of young squirrels? When will they leave the nest? Will we see them? Preggers looks itchy; does she have mange?

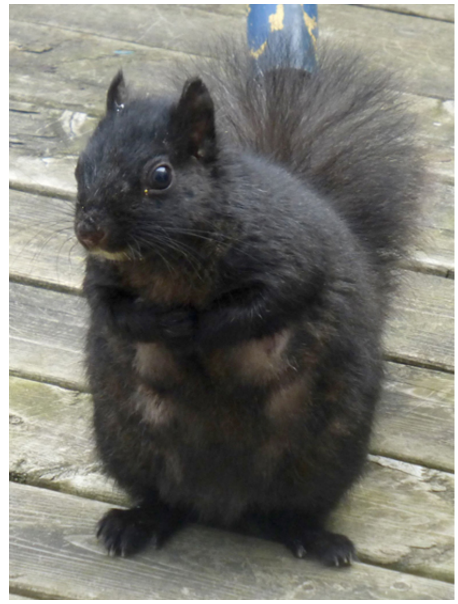

Fig. 11 – Preggers, the pregnant, urban squirrel.

She provides an emotional anchor for the intellectual components of the project portal. The character elicits responses and creates a rapport with the audience—in a similar vein as a documentary film. The character device draws members into the discussion and ensures it consistently revolves around the subject of study.

For SquirrelMapper in particular, Preggers appeals to an important audience demographic: school-age children for which the SquirrelMapper project has created lesson plans for teachers. However, a good, likeable character appeals equally to adults. One only needs to look at the success of the Aflac insurance company's transmedia campaign, Get Well Duck, where they launched a story for the brand mascot, the Duck, in which the character was injured in an accident. Insurance is not typically an interest of children, but the Duck received over 4,000 virtual get well cards within the first three days of the marketing campaign which demonstrates the character's all-ages appeal.

There is an advantage for wildlife monitoring citizen-science projects in that the animals lend themselves more readily to characterization; however, if a transmedia project's narrative is well crafted it can personify environments—like a marine coast or wetland—so media consumers will intuitively anthropomorphize ecosystems as characters.

Adding a character element that is both emotionally and intellectually satisfying (she is cute, we learn about squirrels through her story) increases the desire to interact. That in turn helps drive content explorers towards SquirrelMapper's call to action: counting grey and black squirrels—"Who are the squirrels in your neighbourhood? Tell us!"

3.4 Developing a Media Mix and Content Strategy

Taking Advantage of Existing Tools and Platforms

Over the course of the past decade, several online platforms have been established to facilitate citizen science and public participation in research by hosting several citizen-science projects on a centralized platform for data submissions. Some of the largest and best-known examples include:

- Zooniverse[86] (www.zooniverse.org) – operated by the University of Oxford and Chicago's Adler Planetarium and member institutions of the Citizen Science Alliance
- iNaturalist (www.inaturalist.org) – operated by the California Academy of Sciences
- Project Noah (www.projectnoah.org) – operated by NYU's Interactive Telecommunications Program with backing from National Geographic

These platforms are free for both users and project developers and help remove significant financial, administrative, and operational burdens from small projects and grassroots initiatives. They incorporate mobile apps to facilitate mobile data submissions, as well as social technology for comments, messaging, and forum discussion among participants (many of whom discover and explore additional topics beyond their area of initial interest). Many scientists frequent the platforms and along with advanced/experience users can dispense guidance and knowledge to beginners through informal mentorship.

For the scientists, research-grade data can be easily curated, retrieved, exported and downloaded. For the public participants, many of the participatory motivators are intrinsically fulfilled by these platforms. Such platforms are extremely useful and efficient for observational-recording projects (including basic observational analysis and identification projects), like SquirrelMapper, as well as transcription, image classification and cataloguing projects that can be completed virtually. However, they are not well suited to projects like ANTology, which require physical specimens to be collected and sent to researchers.

In addition to the tools dedicated to hosting citizen-science projects, there are many free, commonly-used social media and communication platforms—Twitter, Instagram, Facebook, YouTube and blogging platforms such as WordPress and Blogger., to name a few—that can serve as avenues for the narrative(s) that orbit and reinforce the main project portal's message.

These platforms also allow for the re-posting and re-sharing of relevant, compelling, third-party content and resources that can supplement and add value to the citizen-science project's channel. For example, a project like SquirrelMapper can feature, high-quality, entertaining content by linking to or embedding *The Nature of Things* episode "Nuts for Squirrels." Curating content is a way to stimulate conversation, add knowledge and value, and improve credibility of SquirrelMapper as an authority and information-provider on squirrels.

Developing a Content Plan

To foster engagement and funnel participants toward project goals with transmedia communication, there needs to be a content plan that:

1. **Assesses the project's situation**: What media channels does it have? What does it need? What limitations are there for time, cost, and technology?
2. **Identify the main audience**: determine who explores the content and who participates in the citizen science
3. **Identifies channel objectives**: how the story will be used as a discovery tool that will prompt media consumers to take action and commit to the citizen-science project.
4. **Outlines a content planning**: determining how the story will fit and be distributed effectively by particular channels.

[86] Trouille, Laura. "Build Your Own Citizen-science project with Zooniverse." Build Your Own Citizen-science project with Zooniverse | American Astronomical Society. American Astronomical Society, 5 June 2017. Web. 10 July 2017.

5. **Develop a publishing schedule**: determine an audience-based posting/publishing schedule that is manageable for the project coordinators (for example, Old Weather posts a new blog entry roughly eight times a year)

By leveraging various channels with a good story, a citizen-science project can expand its reach and help people connect over their shared interests, derive personal benefit by interacting with the project, and motivate them to contribute. Further, using cross-platform, communication opens discussion channels among producers and co-consumers. It offers more opportunities to reach out to and engage with media consumers who share an interest, activity, or common goal. Transmedia narratives add layers of depth and complexity to the content experience that retains consumer (and contributor) interest and builds relationships with the content producers (both the original authors as well as content-generating co-consumers). They offer multiple routes to discovery, interaction, and participation in a common endeavor (i.e., a citizen-science project).

The big-picture goal of the transmedia content plan is to ensure the subject matter of the citizen-science project is the core theme around which all content revolves. Each story element should serve as an intervention that prompts further content discovery and exploration. The narrative-content experience should be satisfying and it should initiate further commitment so that content consumers delve deeper into the project content, sign up for the project, develop community bonds with their contributor peers, and realize the value of their input.

CONCLUSION: CITIZEN SCIENCE IN THE AGE OF CONVERGENCE

In the age of media convergence culture, participants from the general public are subject to preconceived notions with respect to creative input and social interactivity. Participatory culture has conditioned citizen scientists to have expectations of a robust social dimension when they engage with collaborative, contributory platforms and projects. They need to feel that their contributions matter, have value, and affect outcomes.

When they interact with a project portal they need to be intellectually and emotionally satisfied by the content and feel socially connected to the interest-based community within in the project space (whether virtual or in person doing fieldwork.) Participants want to have (and expect to have) some creative input and/or options for creative expression, and derive personal meaning from the project portal and the activities in which they take part.

Top-level organizers and professional researchers that oversee novice-level, biological- and environmental-monitoring projects are concerned primarily with data collection, results and outcomes. They may overlook the opportunities available through highly accessible social media technology and digital platforms. Researchers are also more familiar with technical communication and fact-based exposition and rarely take advantage of narrative as an engagement tool that can appeal to a broad range of related interests, as its value is not immediately evident.

To strengthen engagement and collaboration, even modest-budget projects can leverage digital communication tools to raise their profile by offering more entry-points to their project and build more lasting partnerships with an audience that is interested in their area of study. Key elements they should consider:

- **Position the project as a resource hub for the topic**. Use digital communication tools to create and distribute informative, valuable content, and curate external, third-party material to share and add value with information-rich content on their channels.
- **Ensure the project platform supports a social dynamic** that rewards participation with recognition, feedback, acknowledgement, and attribution. Provide networking opportunities to fuel discussion and cultivate a community.
- **Develop a basic narrative structure** that can be threaded across multiple media modes. It should add personal meaning to content, foster an emotional bond that elicits response, and encourage social engagement and discussion. The narrative should reflect the goals and values of the project, and appeal to some elements of social responsibility.
- **Create more points of entry** to projects by taking advantage of digital communication platforms to propagate the narrative, generate and share related content, encourage user-created content, and invites users (whether they are project contributors or simply content consumers) to influence content distribution

Citizen-science projects have greater outreach potential when their communication initiatives are coupled with compelling narrative content. Stories are spreadable; data entries are not. By leveraging digital communication systems and transmedia storytelling techniques as engagement tools, researchers can recruit and retain more citizen scientist to help them reach their goals.

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