# FACILITATING CITIZEN SCIENCE THROUGH GAMIFICATION

BY

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## Abstract

Gamification is the practice of using game elements to change the experience of non-game contexts. It presents a potentially powerful new approach to motivate volunteers and recruit new contributors to citizen science—the phenomenon of engaging members of the public in the collection and analysis of data in scientific projects. Despite this potential, the efficacy of gamification and its utility in citizen science projects is not well understood. In this thesis, I explore the background literature in citizen science and gamification, consolidating theories about the motivations of citizen science volunteers, game design and research frameworks, and summarize recent studies in the gamification of citizen science. I then present a study on the gamification of NLNature, a natural history-based citizen science project, with the hypothesis that inclusion of gamification features will increase the quantity of volunteer contributions. Challenges in participant recruitment limit the generalizability of the results of this research, but the limitations of this study and their implications for the gamification of citizen science are discussed.

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# Facilitating Citizen Science Through Gamification

The democratization of technology is one of the most profound challenges and opportunities of the 21st century. Ever more accessible personal communications technology is changing industry after industry — from agriculture (Veeraraghavan, Yasodhar & Toyama, 2007) to education (Thornton & Houser, 2005) to financing (Belleflamme, Lambert, & Schwienbacher, 2013) and beyond. In research, one major technology-enabled movement is called “citizen science”.

Citizen science is a phenomenon in which amateur scientists contribute to a research project through voluntarily collecting and/or analyzing scientific data. As Silvertown (2009) pointed out, the idea is not new. Indeed, many of the pioneers of modern science were chiefly not professional scientists but instead made their living through other occupations. However, the proliferation of personal communications technology in the 21st century has led to a “new dawn” for citizen science. Research projects are increasingly designed with citizen scientists in mind (Hand, 2010). Many projects are based on analysis: Foldit, for instance, uses the problem solving skills of the project’s “players” to discover the best structures for protein folding. Others focus on data transcription and processing. Using citizen science for real world data collection, however, is less common.

NLNature is a citizen natural history project. The platform enables participants from around the province of Newfoundland & Labrador to report natural history phenomena. The collected data can then be processed and analyzed by ecologists at Memorial University, allowing researchers to potentially identify trends and make discoveries. NLNature’s significance is underscored by the province’s size and sparse population density: 510,000 people live in the province’s 405,212 square kilometres of land. Moreover, one third of those live in the census metropolitan area of St. John's on the Avalon Peninsula (Newfoundland & Labrador Tourism, retrieved September, 2014). It is therefore relatively difficult for an individual researcher or even a collective of researchers to study provincial trends. It might not be difficult for a population of citizen scientists, however: if participation in NLNature can be facilitated across Newfoundland and Labrador, ecologists can focus on analyzing the sightings instead of collecting the data. The key, of course, is the facilitation of participation across the province. How might we motivate and incentivize users (and potential users) in order to facilitate quality contributions to the project, thereby making it useful to ecologists?

One approach is gamification: the use of game elements in non-game contexts (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011; Deterding, Dixon, Khaled & Nacke, 2011). Game mechanics, dynamics, and aesthetics can be used to drive participation in a non-game, offering the designers of citizen science projects a potentially powerful method of encouraging people to contribute to their project. Gamification, however, is under-researched. What mechanics, dynamics, and aesthetics are the most effective? In which contexts? With which (potential) participants? At present, these questions lack conclusive answers.

Solving complex problems, such as understanding the complex ecology of a 400,000-$km^2$ province while developing technologies that support burgeoning fields like citizen science and gamification, is exactly why the discipline of "design science" exists (Hevner, March, Park & Ram, 2004). Following the process of design science, I first discuss recent trends in citizen science and gamification research, informing the development of the gamification artifacts implemented using NLNature. I then use this artifact in a behavioural study to examine the phenomena of citizen science and gamification, assessing whether gamification might be used to enhance and direct participants' engagement in NLNature and, more broadly, in data collection citizen science projects.

## Background & Related Research

### Citizen Science

As previously mentioned, citizen science is not new. Indeed, from amateur astronomers to Benjamin Franklin, the observations and experiments of hobbyists and non-professionals have been shaping science since before its inception (Silvertown, 2009). Recently, however, technological innovations have brought about a revolution in citizen science. Mobile hardware and software provide consumers with powerful recording and processing capacities wherever they are. The Internet allows the open exploration and sharing of scientific data. Advances in information systems help us to manage, access, and navigate the complex data we collect. Social technologies enable us to build communities of practice and to publicly discuss and debate ideas. These inventions, together, provide amateur scientists with a modern frontier for contributions to citizen science (Newman et al., 2012).

Projects in this new frontier range from butterfly counting and bird-watching to identifying new galaxies and beyond. These projects link amateur scientists from across the globe, uniting hobbyists and creating distributed teams with a common purpose. In tandem, networks and resources for researchers interested in setting up citizen science projects have developed, providing researchers with guides, infrastructure, and even databases of potential participants (e.g., the Zooniverse research collective; Newman et al., 2012). Citizen scientists themselves have developed communities around their practice, sharing achievements and discussing new projects (Silvertown, 2009).

I distinguish between two distinct (but related) citizen science activities: data collection and data analysis. The latter category has arguably received the most attention. In a common data analysis citizen science project, participants are provided with access to large datasets through an online database, such as a photo collection of hundreds of thousands of galaxies. Given some guidance, participants explore these data at their leisure, labeling the galaxies with features and placing them into categories. The sizes of these datasets are typically far too cumbersome for individual researchers to explore efficiently on their own, but by mobilizing the general public through citizen science, researchers have achieved huge results. Galaxy Zoo, a Zooniverse project, is a profound example of success in data analysis citizen science: 100,000 participants produced 40,000,000 classifications of galaxies using this approach, the largest collaboration in astronomical history (Lintott et al., 2008).

As well, there are many exciting data collection citizen science projects. One historical example is the Christmas Bird Count (CBC) organized by the National Audubon Society for over 100 years. Annually between December 14th and January 5th, teams of volunteers in designated areas count all birds they observe over a 24-hour period. As can be typical for data collection citizen science projects, only researchers analyze the massive amount of data collected by volunteers for the CBC. According to Audubon, data from the CBC has been used in over 200 peer-reviewed publications and numerous government reports on conservation and environmental protection ("How the Christmas Bird Count Helps Birds", n.d.). Similar projects extend the idea of citizens as sensors of the environment. In geography, for instance, volunteered geographic information (VGI) or participatory sensing projects are becoming prevalent, mapping everything from cities to epidemiology (Goodchild, 2007).

**Attributes and motivations of citizen scientists.** Who are our citizen scientists? A number of researchers have explored the motivations and identities of citizen science volunteers. In VGI, Goodchild (2007) suggested that exactly who can participate in a given project depends on the project itself. Projects like Wikimapia are open to all, but others such as the Audubon Christmas Bird Count place certain expertise or geographical restrictions on participation. Still others are profession specific (e.g., farmers, military; Goodchild, 2007).

Coleman, Georgiadou, and Labonte (2009) summarized research on participants in VGI projects. They proposed that contributors to participatory sensing projects fall into one of five overlapping categories along a spectrum. Their spectrum begins with the neophyte, an individual with no formal experience in the subject matter of the project, and ends with the expert authority, someone with a proven record and extensive credibility on the subject matter. Coleman et al. (2009) go on to outline eight positive motivators that may motivate a contributor: altruism, personal or professional interest, intellectual stimulation, protection or enhancement of a personal investment, social reward, enhanced personal reputation, creative self-expression, and pride of place. They additionally highlight three negative motivators that might influence someone to contribute to a VGI project: mischief, a personal agenda, and malice or criminal intent (Coleman et al., 2009). Their study, however, is entirely summative, leaving the testing of their motivators to future research.

In a series of focused studies, Nov, Arazy and Anderson (Nov, Anderson & Arazy, 2010; Nov, Arazy & Anderson, 2011a, 2011b, 2014) developed motivational models for different types of user-generated content. In particular, their 2014 study focused especially on online citizen science projects, measuring the relationship between various motivational factors (based on Klandermans' model of participation in social movements; Klandermans, 1996) and the quality and quantity of participants' contributions. Nov et al. (2014) adapted four factors of motivation from Klandermans' model: collective motives (how important the project's goals are to the participant), norm-oriented motives (the participant's perception of important others' expectations of them), reputation (the participant's perceived social standing relative to the project community), and intrinsic motivation (the enjoyment gained from participating in the project). Taken together, these factors are shown to explain between 31% and 46% of variance in contribution quantity across the three citizen science projects surveyed. Collective motives by far are the most important influence on the quantity of participants' contributions, followed by intrinsic, then reputation, then norm motives. The correlates of these factors and quality, however, tell a different story. While collective motives had a similar effect on contribution quality as they did on quantity, norm-oriented and intrinsic motives actually had a negative effect. The authors suggest that norm-oriented and intrinsic motivators are sufficient enough to engage a basic level of contribution but not enough to exert the additional effort required for high-quality contributions (Nov et al., 2014).

Nov et al. (2014) suggest that these results reveal a crowding effect common to environments that foster trusting reciprocal relationships between members and administration. A crowding effect implies that intrinsic motivations will be reinforced by extrinsic motivations, as long as extrinsic motivators (e.g., reputation) allow for participants' self-determination and do not undermine their intrinsic motivators. The authors also suggest that the pattern of results observed in their study is evidence that improving contribution quantity does not necessarily improve contribution quality (Nov et al., 2014). These are important lessons for designers of socio-computational systems for citizen science.

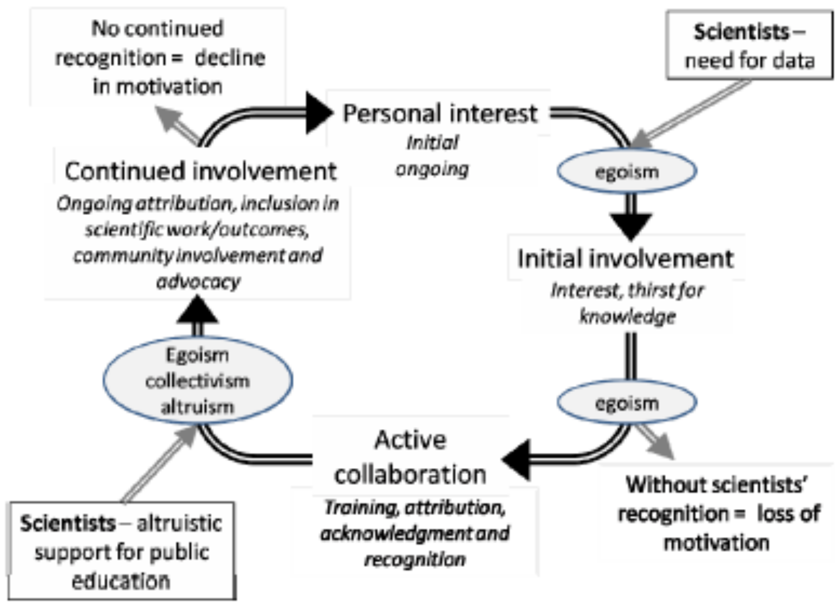


*Figure 1*. A cyclical model of volunteer and researcher motivations in citizen science. Adapted from "Dynamic Changes in Motivation in Collaborative Citizen-Science Projects" by D. Rotman, J. Preece, J. Hammock, K. Procita, D. Hansen, C. Parr, D. Lewis, and D. Jacobs, 2014.

Rotman et al. (2012) provided a final perspective on the motives of volunteer citizen scientists by testing the motivations of self-identifying volunteers against Batson, Ahmad and Tsang's (2002) motivational model for social participation. This model describes four types of motivation: egoism (where an individual is motivated to improve their own welfare), altruism (where an individual is motivated to improve the welfare of another individual or group), collectivism (where an individual is motivated to improve the welfare of a group they belong to) and principalism (where an individual is motivated to act on principle). Perhaps surprisingly, their results reveal that volunteers are motivated most by egoism. While these results clash with those of Nov et al. (2014) discussed above, Rotman and her colleagues go on to propose a cyclical model of motivation in which a volunteer's initial contributions are driven by egoism, but as they are included in the community and become connected to the project's purpose, their motivations shift toward collectivism, altruism, and principalism (see Figure 1; Rotman et al., 2012). This may mean that the Nov et al. (2014) research focuses too much on current members of citizen science communities. This is an important area of future research, but the questions that remain are outside the scope of the present study.

**Challenges of citizen science.** The success of a citizen science project depends, broadly, on the credibility of the content generated by its users (Flanagin & Metzger, 2008). Information credibility depends on two major dimensions: the quality and the quantity of user generated content (UGC). Information quality can be defined as the information's fitness for use by the information consumer and depends on a number of important factors. The most salient factors in the quality of UGC, however, are information accuracy and completeness. Information accuracy is the extent to which the data correctly represent the subject, while information completeness is the extent to which the data capture all available information about the subject (Wang & Strong, 1996). Conversely, the number of contributors and the amount they contribute are factors of information quantity. A common assumption in citizen science research is that there is an implicit trade-off between information quantity and quality: as more participants are recruited to contribute to a given citizen science project, less of them have an expertise in the subject area (as, in general, expertise is rare). As experts are considered the most reliable source of quality information, diluted expertise in participant contributions implies a reduced data quality (Lukyanenko, Parsons & Wiersma, 2011; Coleman et al., 2009).

Proposed solutions to the citizen science data quality problem include providing training to participants, using experts to verify contributions, and using social feedback (e.g., allowing participants to review, correct, and provide feedback on one another's work). Solutions also exist in the design of the socio-computational systems on which citizen science projects are based.

Research has demonstrated, for example, that the information system used to manage data matters: use of an instance-based conceptual model not only allowed participants to provide more complete contributions but also resulted in an increase in the number of contributions participants make (Lukyanenko, Parsons & Wiersma, 2014a, 2014b). Further research showed that citizen science projects might increase the quantity of contributions by designing contribution opportunities to be small and manageable, independent, and personalized (Eveleigh, Jennett, Blandford, Brohan & Cox, 2014). Another approach to enhancing participation also emphasizes the design of the user experience: gamification.

**Games, Game Design, and Gamification**

At the root of gamification theory is the game, but what is a game? How do we understand, design, and evaluate games? What does gamification look like? Why is it important, and how might gamification be done and used effectively? These are some of the key questions I will explore in this section. First, I explore the foundations of modern game studies. Second, I examine several influential game frameworks in depth, finishing that discussion by highlighting a recent model (the MTDA+N framework; Ralph & Monu, 2014) that attempts to synthesize these frameworks into a cohesive whole. I then discuss gamification and its origins.

Much like citizen science, games are an old phenomena that have only recently gained the attention of a deliberate research community. Game theorists in math and economics have used games and risk in research on behaviour (cf. Neumann & Morgenstern, 2007), but these studies have focused on reductive game models that do not conceptually resemble the complex features of "real-world" games (Björk & Holopainen, 2003). Similarly, researchers in the humanities have made valuable contributions to game studies from cultural perspectives. In seminal texts, Huizinga (1949) and Caillois (1961) explore games and play in the context of sociology, arguing that play (and games by extension) is voluntary, adaptive, and necessary for the formation of society. Their ideas inform and support the study and design of games and gamification (Fuchs, Fizek, Ruffino, & Schrape, 2014), but they do not define what games are, nor offer a way to understand and evaluate our success and failure in the design of games and gamification. Instead, the work of Huizinga (1949), Caillois (1961) and others built the foundation upon which many game study frameworks now stand.

**Game Frameworks.** In the early 2000s, many researchers sought to establish theories, taxonomies, and models for the study, design, and analysis of games (see Björk & Holopainen, 2003; Björk, Lundgren, & Holopainen, 2003; Lindley, 2003; Lundgren & Bjork, 2003; Rocha, Mascarenhas, & Prada, 2008; Sicart, 2008; Zagal, Mateas, Fernández-vara, Hochhalter, & Lichti, 2005). Three works in particular hold influence: Hunicke, LeBlanc, and Zubek's Mechanics, Dynamics, and Aesthetics (MDA) framework (2004); Schell's Elemental Tetrad framework (2008), and Jenkins' (2004) ideas about games as narratives. I will discuss these three models in detail before discussing a fourth model in which the three models converge: Ralph and Monu's (2014) MTDA+N framework.

The MDA framework of Hunicke et al. (2004) is a hierarchical model in which games are more artifact than media, they provide context, not content. In other words, the content of a game is the behaviour that emerges from the game, not the game itself. In this framework, mechanics are the building blocks of games. Mechanics are the mechanisms of action and control selected and built by the designer. Dynamics emerge from the interactions of the player and the mechanics—they are the systems of behaviour creating the game context. Aesthetics are the emotional responses evoked in the player by the gameplay. Designers create specific dynamics with the mechanics they choose, while players experience different aesthetics due to how they interact with the game's dynamics (Hunicke et al., 2004). In this way, the MDA framework formally bridges game design with game experience and research.

Schell's Elemental Tetrad (2008) conversely characterizes games as content with four separate components: mechanics, technology, aesthetics, and story. Schell's version of mechanics and aesthetics parallels the MDA model of Hunicke et al. (2004), albeit simplifying aesthetics to mean the perceptual elements (e.g., sights, sounds) of the game. Technology refers to the devices and materials used to deliver the gameplay experience. Finally, story defines the game's sequence of events from beginning to the end objective (Schell, 2008). Schell's model therefore focuses less on the game experience and is not as effective for connecting game design to game experience as the MDA framework. However, technology and story are important pieces of game design arguably missing from the MDA framework. The same game mechanics (e.g., an explorable game world) can be implemented in many different ways (a cardboard game board, a virtual world), each creating a different game experience. Similarly, the same game can be built with different stories, again creating a different experience for the player. Thus, the Elemental Tetrad and the MDA framework each include distinct aspects of a cohesive game theory.

Jenkins (2004) extols games as narratives, going beyond Schell's (2008) definition of a story to define four types of game narratives: evoked, enacted, embedded, and emergent. An evoked narrative is one in which the player participates in a familiar world (e.g., a game set in the Star Wars universe). In an enacted narrative, the player completes objectives plotted by the designer (e.g., playing as Luke Skywalker during the Battle of Hoth in a Star Wars game). An embedded narrative is conversely a static story witnessed by the player as they interact with the game world (e.g., discovering what happened to the Jedi through exploring our Star Wars example). Finally, an emergent narrative is the story that players create and construct themselves when given freedom in a game (e.g., in a round of Trivial Pursuit, is the story about who knows the right answer to a specific question about the Black-capped Chickadee, or is it about who in the room is an expert on birds?). Jenkins' (2004) exhaustive discussion of game narratives defines the final missing piece for a comprehensive game model.

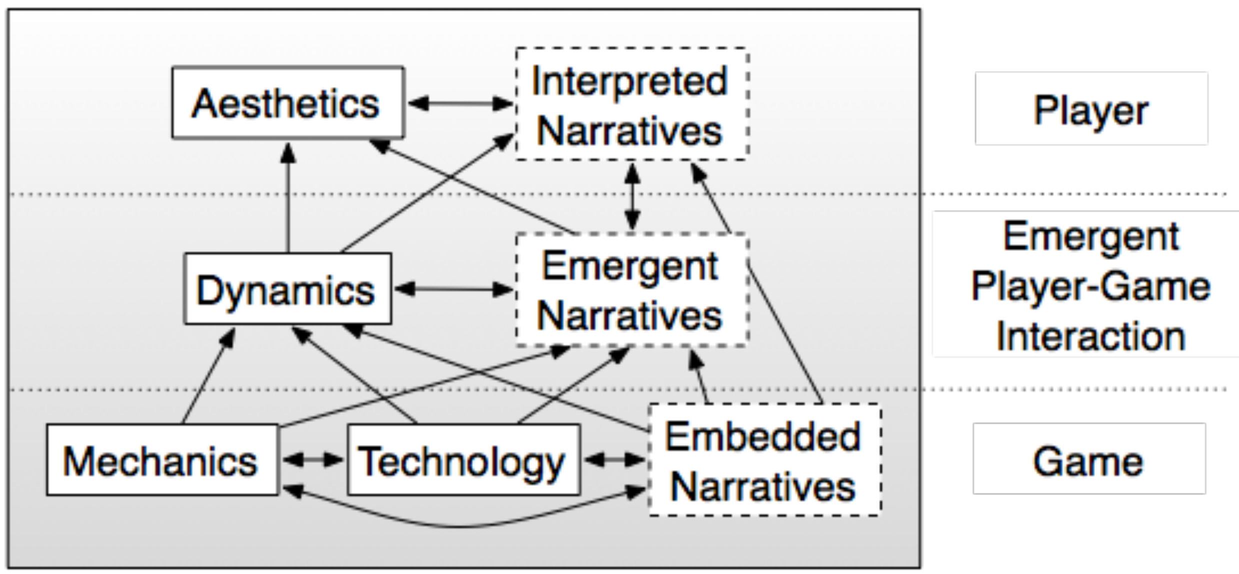


*Figure 2.* The MTDA+N Game Framework. Adapted from "MTDA+N: A Working Theory of Game Design" by P. Ralph and K. Monu, 2014.

Ralph and Monu (2014) synthesize the models discussed above into a cohesive, functional theory (see Figure 1). MTDA+N includes Hunicke et al.'s (2004) mechanics, dynamics, and aesthetics, Schell's (2008) technology and story, and expands story to include many of the features of game narratives discussed by Jenkins (2004). The synthesis of the three frameworks into the MTDA+N model implies that it would offer the greatest explanatory power of these frameworks. This allows researchers to examine each aspect of game experience while understanding how those aspects are created by designers and engaged with by players (Ralph and Monu, 2014). Overall, this model will help us to understand the design process and to evaluate our success as we examine the gamification of a citizen science project, NLNature. First, however, we must explore gamification itself.

**Gamification.** Gamification has had a tumultuous history. In the early 21st century, marketers, entrepreneurs, and consultants popularized gamification in commercial applications. To many, gamification has become a buzzword, and gamification processes are being used to exploit rather than to benefit consumers (cf. Bogost, 2015, for an example of this perspective). Yet the idea still holds great promise. Many gamification designers and researchers discuss flow: Csikszentmihalyi's highly regarded conceptualization of the optimal human experience (and how to facilitate it; Csikszentmihalyi, 1990). Gamification may be the key to unlocking states of flow: to make any experience engaging and rewarding, no matter how mundane or difficult (Deterding, 2014).

As previously mentioned, Deterding et al. (2011) have established a widely accepted definition of gamification: the use of game elements in non-game contexts. In practice, the context varies widely. Gamification has been applied to education and learning (Garris, Ahlers, & Driskell, 2002), promotions and marketing (Huotari & Hamari, 2012), question and answer services (Mamykina, Manoim, Mittal, Hripcsak, & Hartmann, 2011), human resources (Thom, Millen, & DiMicco, 2012), self-help and health (McGonigal, 2012), citizen science (Newman et al., 2012), and beyond. In many of these cases, the design of the gamified system is simple: offer points as some quantified measure of contribution or value in return for player participation and success (Fuchs et al., 2014). As explored in the discussion on game design, however, there is more to games than point systems, and gamification designers should seek to go beyond these implements in the creation of gamified experiences. This, Deterding (2014) argues, is the future of gamification: experiences that motivate, nudge, and guide people and society towards positive behaviours. In science, there is latent potential in the engagement of the public as participants and contributors in the collection and analysis of research data. Critically, gamification might be a pathway towards unlocking this potential.

**The Gamification of Citizen Science**

Despite the considerable attention that gamification has received (e.g., Hand, 2010), it is under-researched in the context of citizen science. The preeminent example of gamified citizen science is Foldit, a system that makes protein folding an online multiplayer puzzle game. Foldit complements the Rosetta protein structure prediction methodology with the spatial reasoning and decision-making abilities of human players. The Foldit team has enjoyed huge success: human players using the system match the abilities of automated protein-folding algorithms on three out of ten puzzles and actually outperform the algorithm on five out of ten puzzles (Cooper et al., 2010). Foldit stands as an exemplary model for the gamification of data analysis citizen science. Unfortunately, no such model exists for the gamification of data collection. Moreover, Foldit is a complicated game that benefits from the puzzle-like nature of protein folding. Can similar levels of success be reached with gamification outside of this context?

Foldit notwithstanding, the literature on the gamification of citizen science is relatively sparse. Prestopnik and Crowston (2012a, 2012b) and Crowston and Prestopnik (2013) examined several citizen science game artifacts, conducting focus group interviews and testing user experience in two separate exploratory studies. They distinguished between two gamification approaches: the integration of game mechanics within a citizen science task ("Task Gamification") and the inverse, the integration of a citizen science task within a game ("Game Taskification"). In a task gamification paradigm, designers add game elements to a previous task (e.g., classifying images) in order to make the completion of that task more engaging or enjoyable. Game taskification is the inverse approach: designers build a game in which tasks are a subcomponent. In either case, Prestopnik and Crowston's (2012a, 2012b) experience showed that gamification could be costly and complicated, creating friction between the research goals of the citizen science project, the feasibility of the game artifact (especially if it is a full digital game), and the problem space itself.

Nonetheless, the early findings of Crowston and Prestopnik (2013) provided further evidence that even simple gamification has potential. In a trial of an online digital matching game, participants were able to accurately identify the correct match a sufficient number of times to create useful data were the project contributing to a real citizen science project (the authors note, however, that the game would need a large number of players to create these data). Further, one-third of players continued playing beyond what was required to receive the incentive for the study, perhaps indicating that game features are motivating for some participants. In an exit survey, participants reported that competitive features and the knowledge that the game was helping scientists would both motivate them to play more (Crowston & Prestopnik, 2013). I note, however, that these studies were exploratory; the results reported did not undergo any statistical hypothesis testing nor confirmatory data analysis.

Tiger Nation is another early example of research in gamified citizen science (Mason, Michalakidis & Kraus, 2012). Tiger Nation is a citizen science platform focused on the protection of wild tigers in India. The system enables sophisticated tracking of individual tigers across time and space by empowering eco-tourists both to provide their photos of tigers photographed in wilderness reserves and also to help identify unique tigers in these photographs. The citizen science gamification artifact is Tiger Match, a simple matching game in which participants compare two photos of a tiger and are asked if the two photos are of the same tiger.

In this way, the system compiles "votes" from the crowd of participants and uses these votes to supervise an automated matching algorithm. Crucially, however, the authors evaluate their approach through a private beta of the software in which only 20 tiger-spotting experts participated; more robust testing is necessary before Tiger Nation can be considered a success of gamification.

Few other examples of research on gamification in citizen science exist. Crowley, Breslin, Corcoran and Young (2012) reported on a gamified mobile application for VGI participatory sensing. Similarly, Yanenko and Schlieder (2014) presented a proof-of-concept VGI game focused on improving the quality of crowd-collected data through retesting and confirmation. These examples make the case for lightweight mobile social games to help a communities recognize issues in their local environment, but do not present any results for discussion.

In another set of studies, Bowser, Hansen and Preece (2013) and Bowser et al. (2014) examined users' experiences with the applications, contrasting participants who self-identified as citizen scientists versus participants who identified as gamers. Early results echo Prestopnik and Crowston's concerns: it is important to distinguish between "gamifying" a task and "taskifying" a game, as different approaches will appeal to different groups in different ways. Cursory feedback reveals that people who identify as amateur scientists eschew highly game-like interfaces, for example (Bowser et al., 2013).

Last, a preliminary study examines volunteer motivations in gamified citizen science. Iacovides, Jennett, Cornish-Trestrail and Cox (2013) conducted semi-structured interviews with a small sample of citizen scientist volunteers from Foldit (previously discussed) and Eyewire (a citizen science game that involves colouring in different sections of images of mouse retinal tissue, helping neuroscientists map the connections between neurons). Though small in sample size and qualitative in nature, the findings suggested that gamification does not make a citizen science project more attractive to potential volunteers; volunteers signed up for their respective projects because they were interested in the science. The results also suggested, however, that game features may sustain participants' engagement in a citizen science project, and the authors suggest building meaningful game mechanics and social features are important aspects of gamification in citizen science contexts (Iacovides et al., 2013).

Ultimately, these studies offer little evidence for the viability of gamification in citizen science. Not only is there little existing literature on the gamification of citizen science (and even less focused on data collection citizen science), but the extant research is largely exploratory, doing little in the way of robust evaluation and hypotheses testing. Moreover, none of the research I reviewed provided experimental control. There is consequently a profound need for controlled experimental research in gamification, and that is the aim of the present study.

**Design Science**

Rooted in engineering, design science is a problem-solving paradigm that emphasizes the building of technological innovations in response to human and organizational needs (Hevner et al., 2004). In Information Systems (IS), design science provides a conceptual approach with which to tackle real-world challenges while advancing IS research. The design science process provides solutions to complex challenges (e.g., the gamification of a citizen science platform), while simultaneously developing an innovative IS tool—the design artifact—with broad application. In this study, NLNature is such an IS artifact. We apply the lessons learned through reviewing the literature in the development of gamification features for the platform. In turn, I present a behavioural experiment that allows us to explore the viability of gamification in citizen science while also developing tools that help to advance the theory and practice of gamification in IS.

### Hypotheses

Our hypothesis was that basic gamification, implemented through a program of quests, events, and rewards for completion of those quests and participation in those events, would result in more contributions provided by citizen scientists on NLNature than in the control group. This hypothesis was inspired by success observed in other studies (see Bowser et al., 2013; Bowser et al., 2014).

## Methods

### The Artifact

NLNature (http://www.nlnature.com; see Figure 2) is a citizen science platform used to collect sightings of wildlife in the Canadian province of Newfoundland and Labrador. Contributors who register an account are free to post reports of any and all of the flora and fauna they encounter in the province. In a given sighting, users select the date and time of the sighting, the location of the sighting (either on a map or in latitude and longitude coordinates). They then identify their observation as best as possible and/or provide a description of the features of their sighting. Finally, they upload any photos of their observation (if available) and submit the sighting. Figure 3 illustrates the user experience of this process. Elsewhere on the site, users can see the observations posted by themselves and other users (either on a map or in a timeline), help classify unidentified sightings, comment on sightings, and more.

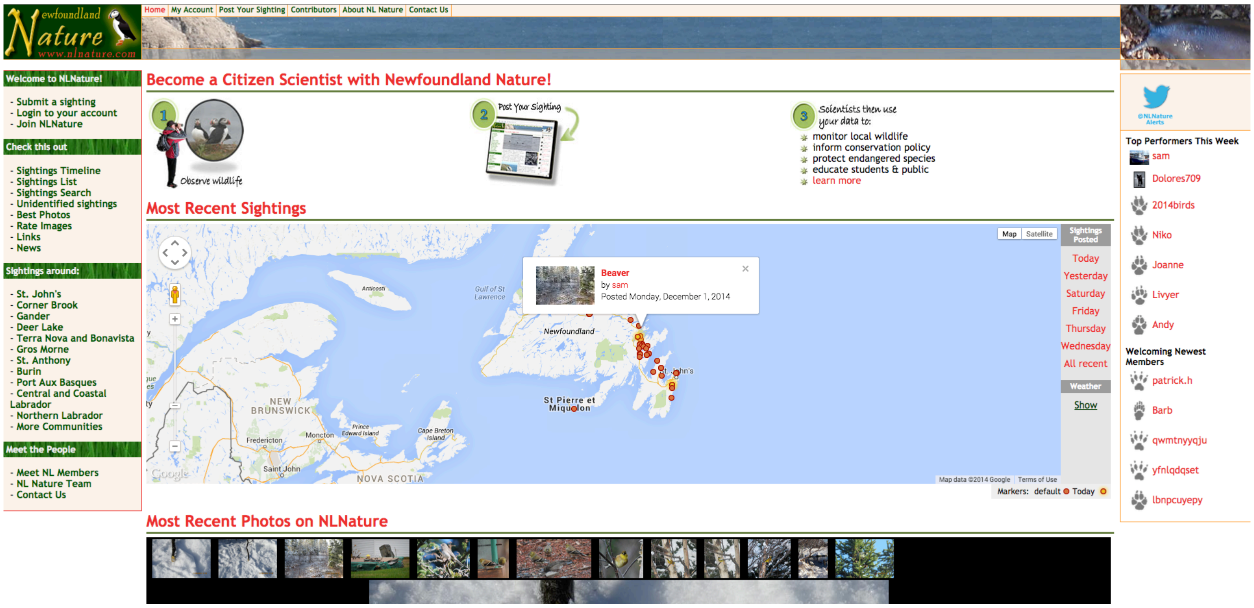


*Figure 3*. The NLNature website.

The key features of the website pertaining to this study are game mechanics implemented for the purposes of this research: Quests and Events. The list of Quests, Events and their framing differ between the treatment and control conditions in the study and are included in the appendix. Participants in the treatment or game condition are required to complete the provided Quests and to participate in at least two events in order to complete the game and receive a reward: a certificate recognizing the participant as an Honorary Citizen Ecologist with NLNature. This certificate is of no actual value nor does it provide any credentials to the bearer; it simply represents the participants' significant contributions to the NLNature platform.

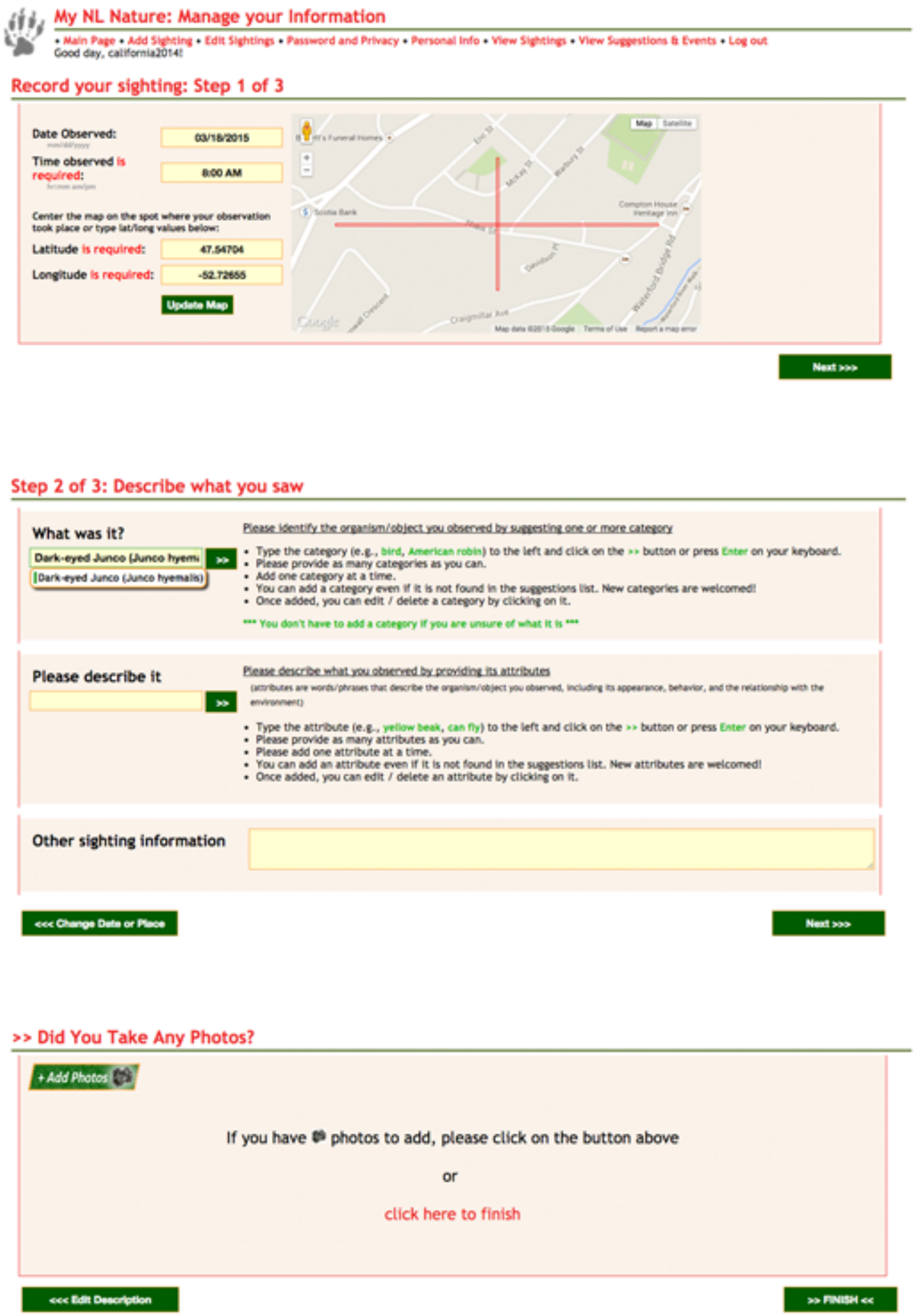


*Figure 4.* The NLNature observation reporting process.

**Participants**

Participants were recruited from a population of approximately 500 students in first- and second-level undergraduate Biology courses at Memorial University in the Winter semester of the 2014-2015 academic year. During an in-class presentation, NLNature was explained to the students by the principal researcher. The presentation described the purpose of the website, how to contribute, and some examples of contributions we've observed in the past. The study itself was then introduced and its purpose was summarized. Students were then instructed that they would be entered in a draw for one of two $50 gift cards by registering for the study on NLNature at a given link. At the end of the registration period (approximately one week after the last class presentation), 17 participants had registered for the study.

Registering an account initiated participation in the study. Once registered, students were prompted to agree to the Terms of Participation (see attached) and they could not register for the study without agreeing to these Terms. Upon registration, participants were randomly assigned to the treatment condition or to the control condition. They were then sent one of two potential welcome emails depending on the condition to which they are assigned. These emails highlighted the gamified features of the website (or placeholder features for the control group). Further, for the treatment condition, students were instructed that they would receive a certificate making them an Honorary Citizen Ecologist from NLNature by participating in the game features of the website.

**Procedure**

Upon online registration for the study, participants received an email containing different instructions depending on whether they had been assigned to the game or to the control group. Students in the game condition were told that they would receive a certificate of recognition &

achievement for completing 10 Quests (such as the Birdwatcher Quest: “Throughout the semester, record 5 different bird species of any kind.”) In contrast, the control group was given suggestions on how to contribute to NLNature that paralleled these Quests. These Quests or suggestions were displayed to participants on the main page of the website and also were accessible in their account dashboard. Both groups were further encouraged by email to participate in NLNature Events throughout the study period (for instance, the Bird Blitz Event: “We’re looking at the birds this weekend. Record every bird you observe!”). In addition, throughout the study, students in the game condition who completed quests and participated in events were congratulated via email with a message that thanked them for their contributions to NLNature; students in the control condition were regularly emailed with similar expressions of gratitude for their individual contributions to the site.

Throughout the study period, lasting approximately 3-6 weeks depending on when participants completed registration, participants were free to report sightings of any ecological phenomena on the NLNature platform. The process of submitting sightings was the same for the treatment and control groups of this study as it was for regular users of the site, consisting of a date and time, a location, and identification of the species or a description of the phenomena. They may have also included photos and commentary. Participants’ sightings were automatically collected in the NLNature database and manually coded to assess for Quest completion (or for fulfillment of suggestions, in the control group).

## Results

Table 1 displays descriptive statistics describing the overall results of this study. Only one participant across both groups submitted any sightings during the study period: a member of the control group! That member submitted two sightings. The two sightings submitted by the member (incidentally, a Blue Jay and a squirrel) were sighted at the same date, time, and location.

Table 1.

*Summary of participants' contributions.*

| Condition | Number of participants | Sightings Reported Mean | Standard Deviation |
|---|---|---|---|
| Control | 8 | 0.25 | 0.71 |
| Game | 9 | 0 | 0 |

## Discussion

Gamification, the use of game elements in non-game contexts, promises a simple, cost-effective method of improving contributions to citizen science. This study served to assess the power of gamification to motivate participation and provided an opportunity to construct and evaluate a new gamification artifact. We designed new game features for an ecology citizen science platform, NLNature. We then set out to explore whether gamification might encourage new participants to contribute more to a data collection citizen science platform, especially in contrast with a non-gamified platform. We were met with challenges falling into two categories: study registration and active participation. Further research will be required to validate the utility of gamification. Here I discuss those challenges, speculate about the study's limitations, and discuss next steps for research in the gamification of citizen science.

**Limitations.** The study was promoted to 401 students in a first-year Biology course and three different second-level Biology courses each with over 100 students. Even assuming that many of the students in second-year Biology are enrolled in the same courses, the targeted promotion of the study reached over 500 students. With these efforts, only 17 students registered for the study (approximately 3.2% of the targeted population). This low registration prevents us from generalizing the findings of the present experiment. For several reasons, however, I am cautious to suggest that this turnout implies a failure of gamification or of citizen science.

The undergraduate student population we sampled from is characteristically busy and stressed. In a recent health survey, 52.7% of students stated that their academics had been traumatic or very difficult to handle in the last 12 months and 35.5% of students stated the same for their finances. 45.2% said that they experienced “more than average” stress and another 10.9% shared that they experienced “tremendous” stress (American College Health Association, 2013). While these figures are not explicitly linked to the present research, they point to a potential barrier preventing the successful recruitment of undergraduate students. This problem may have been exacerbated by the structure of this study, which may have appeared to require effort students could not spare in their day-to-day lives.

The cyclical model of volunteer motivations proposed by Rotman et al. (2012) suggests another reason for our present recruitment difficulties. They suggest that initial participation in citizen science projects stems from egoism: personal interests that may be tangential to the project itself, but serve the volunteer. According to the model, volunteers become involved in a citizen science project because they find it enjoyable or they are seeking to broaden their own horizons. In our promotions for NLNature, we emphasized the scientific value of the platform, not the value it could have provided to the students. Indeed, Rotman et al.’s (2012) model suggests that we would have had more success had we promoted the gamified features!

A third barrier to recruitment may have been the seasonal weather of the study period. Time constraints limited our ability to recruit and run this study at a different time of year, but I recognize the inherent paradox in recruiting students to participate in an outdoor natural history project during the winter months in St. John’s, NL. It is likely that this factor affected both participant recruitment and participant contributions.

It is also possible that instantiation validity posed a problem for participant contributions. Instantiation validity is an aspect of experimental validity unique to design science and analogous to research and survey design validity. It is the degree to which an IT artifact represents the theoretical construct it is used to study (Lukyanenko, Evermann, & Parsons, 2014). As stated by Gregor and Hevner (2013), the functioning of an IT artifact is not sufficient to establish instantiation validity: the artifact must also succeed in doing what it is meant to do. For instance, while Quests and Events are undeniably game mechanics that could change the user experience of the NLNature artifact, it is possible that they are not implemented effectively or that they do not represent effective gamification. In this way, NLNature and its game mechanics may not have achieved instantiation validity in its present iteration, implying that the artifact itself would be flawed, but not the theory behind it. Alas, evaluation of the artifact is outside of the scope of the present study; whether we achieved instantiation validity is thus an objective for future research.

**Conclusion**

Ultimately, due to low registration in the research study I present here, I hesitate to generalize any conclusions from this study to gamification as a whole. Nonetheless, the lack of contributions in the gamified condition suggests that the game mechanics implemented here did not motivate participants more than those in the non-gamified artifact. The barriers to registration and participation I discuss above are important considerations for future gamification and citizen science research, however. I hope these lessons are instructive for future studies.

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Appendix

**Treatment group Quests**

*Did you know? The participants who complete each of the following quests by the end of the study period will receive a certificate recognizing them as honorary ecologists on behalf of NLNature.*

**Birdwatcher.** Record at least 5 different bird species in any area other than at a bird feeder.

**Feeder frenzy.** Record at least 5 different species of birds that you observe at a backyard bird feeder.

**Top trees.** Record at least 5 different species of trees in their natural habitat.

**Winter wonderland.** Find and report at least 5 sets of animal tracks of different species in the snow. Your own pets don't count!

**Uncover the urban.** Some animals can thrive in urban environments. Report at least 5 different species of wild plants or animals (no domestic pets/garden plants) in an urban or suburban area.

**Cool coastal.** Newfoundland and Labrador has extensive coastline along the ocean edge. Report at least 5 different species of plants or animals that live in coastal environments.

**Small mammal surprises.** Small mammals can be hard to spot! Report at least 5 mammal species sightings. Multiple observations of the same species are okay.

**Super scat.** Often the best way to detect mammals is through their scat (poop). Report at least 5 different kinds of mammal scat.

**Winter Whales.** Whales can still be spotted off the coast of Newfoundland in the winter. See if you can spot one! Report any 1 whale sighting in the winter months.

**Control group Suggestions**

*The following are a list of useful ways you might be able to contribute to NL Nature.*

**Birdwatcher.** Record different bird species you find in any area other than at a bird feeder.

**Feeder frenzy.** Record different species of birds that you observe at a backyard bird feeder.

**Top trees.** Record different species of trees in their natural habitat.

**Winter wonderland.** Find and report sets of animal tracks of different species in the snow. Your own pets don't count!

**Uncover the urban.** Some animals can thrive in urban environments. Report different species of wild plants or animals (no domestic pets/garden plants) found in an urban or suburban area.

**Cool coastal.** Newfoundland and Labrador has extensive coastline along the ocean edge. Report different species of plants or animals that live in coastal environments.

**Small mammal surprises.** Small mammals can be hard to spot! Report different mammal species sightings. Multiple observations of the same species are okay.

**Super scat.** Often the best way to detect mammals is through their scat (poop). Report the different kinds of mammal scat you come across.

**Winter Whales.** Whales can still be spotted off the coast of Newfoundland in the winter. See if you can spot one! Report any whales you sight in the winter months.

**Events**

***Non-competitive group explanation.*** *Participate in at least two of the four events below in order to be eligible for the citizen scientist's certificate.*

***Control group explanation.*** *If you're looking for an excuse to contribute to NL Nature, check out the below events!*

**Winter wonderland.** Go for a walk this wintery week and report everything interesting that you see!

**Bird blitz.** We're looking at the birds this week. Record every bird you observe!

**Shoreline sightings.** Visit a shoreline or coastal area this week and record as many sightings as you can.

**Dedicated deciduous.** Deciduous trees are somewhat uncommon in Newfoundland & Labrador than their coniferous counterparts, and they lose their leaves during the winter. Record as many deciduous trees as you come across this week!