Collaborative Scientizing in *Pokémon GO* Online Communities

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Abstract: Finding and applying science practices in everyday contexts (scientizing) is a powerful way for people to engage in science learning. This paper examines how people collaboratively scientize through a massively multiplayer mobile game called *Pokémon GO*. For three months, we conducted observations of online communities around *Pokémon GO* and examined how crowdsourcing engagements in these communities can lead to science inquiry. We adhered to the standards of a comparative case study to examine three exploratory cases of scientizing in online discussion about *Pokémon GO*. These examples include crowdsourcing collaborations to compare multiple data sets, countering misinformation, and creating mapping sets. We demonstrate how aspects of these online engagements follow authentic and simple science inquiry. Furthermore, the implications of our research for informal science learning are especially meaningful for understanding how *Pokémon GO* can be used to motivate scientizing practices in families and children.

Introduction

One goal of science education for youth is to produce scientifically literate citizens that are able to actively apply science in their everyday lives (Rutherford, & Ahlgren, 1990). Yet, for many learners, science learning is abstract and connecting science learning to everyday practice is challenging (e.g., Lee & Fradd, 1998). Researchers have attempted to understand how learners engage in everyday science practices, through interest-driven learning (Edelson & Joseph, 2004), connected learning (Ito et al., 2013), and the tailored practice of hobbies (Azevedo, 2013). One concept we have adopted to understand how people engage in science learning and practices on their own terms is the notion of "scientizing." Clegg and Kolodner (2014) define scientizing as the ability to ask questions about how the world works, searching to understand knowledge in the world, recognizing the gaps in one's own understanding to accomplish goals, and investigating personal scientific questions. Today, we live in digital age of crowdsourcing of knowledge and information; people create complex projects and can break it down to simpler tasks that many other individuals can contribute to. Within different online communities, people can connect and communicate with each other over distances and time using information communication technologies (ICT). However, we do not yet have a deep understanding of how online crowdsourcing can promote scientizing practices.

In this study, we are exploring scientizing and online crowdsourcing in the context of *Pokémon GO*, a massively multiplayer online (MMO) augmented reality game (ARG). We are specifically examining *Pokémon GO* because the location-based nature of the game encourages collaborative and participatory efforts for players to collect data in the world. Additionally, because *Pokémon GO* has a wide mainstream appeal, we believe it has a strong potential to motivate children and families in scientizing practices. For three months, we observed a series of discussions in online communities in how players engaged in problem solving tasks around *Pokémon GO*. The goal of *Pokémon GO* is for players to capture virtual creatures (Pokémon). Despite the simplicity of the game, the developers (*Niantic*) are often not forthcoming about the game mechanics. Because of the lack of transparency, players have come together online to crowdsource and reverse engineer how the game works. Based on our online observations, these collaborative efforts present a compelling case for using ARGs to engage people in scientizing practices via their own interests.

This case study addresses multiple gaps in knowledge in research. First, we lack a clear understanding of how scientizing takes place on an open massive online scale. Second, little is known about how scientizing takes place as people reverse engineer a sociotechnical system of their own interest. In this study, we explore the following research questions: ***RQ1***: How do these massive, online, crowdsourced projects inform us about how people can engage and openly collaborate in everyday science practices?; and ***RQ2***: What science inquiry practices exist as game players try to collaboratively investigate a sociotechnical system of their own interest? From our observations, we present three case studies of *Pokémon GO* and online crowdsourcing. We analyze each case study using a framework of scientizing and Chinn and Malhotra's (2002) scientific inquiry practices. Finally, we conclude with a discussion on how online crowdsourcing for scientizing can be used to motivate for families and youth in science learning.

Background

Augmented Reality Games and *Pokémon GO*

Pokémon GO is usually called an ARG, a term which has become intertwined with mixed reality (or hybrid) game (i.e., a game which has both digital and real-world components) and location-based mobile game (i.e., LBMG: a digital game available on mobile platforms dependent on player location) (Rashid, Mullins, Coulton, & Edwards, 2006). Many ARGs are also labeled as pervasive games—taken from the field of pervasive (or ubiquitous) computing—which are "digital games that move beyond the traditional computer interfaces and into the physical world to occupy time and place on a human scale" (Falk & Davenport, 2004, p.127). *Pokémon GO* is also a MMO game, as all players are simultaneously online participating in one global game environment. In *Pokémon GO,* players use the game software to locate and catch Pokémon that appear in real-world locations. Three player factions use captured Pokémon to battle for control of virtual Gyms, which are mapped onto real-world locations. Other locations, termed PokéStops, allow for the collection of game resources. While Gyms and PokéStops are permanent virtual features, "wild" virtual creatures are subject to game mechanics that govern the location and frequency of their availability. While commercial digital games have been available since the 1970s, ARGs take advantage of consumer devices and GPS satellites affording highly accurate positioning information. *Pokémon GO* has achieved popularity unlike any of its predecessors (i.e., early ARGs like *Ingress*), and introduced millions of new players to the genre.

Scientizing in online gaming communities

Scientizing in online gaming worlds can be a specific designed experience in virtual worlds. For instance, Asbell-Clarke et al. (2012) developed *Martian Boneyards*, a MMO game focused on using tools for scientific inquiry within the storyline. Educational multi-user virtual environments, such as *Quest Atlantis* (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005) and *River City* (Ketelhut, 2007) have demonstrated evidence that learners can engage in collaborative scientific practices and activities in online gaming environments. A growing body of research is also examining how scientific practices take place in commercial digital games and their related online communities. Similar to gaming, online communities around games are contexts in which people work together in knowledge building communities (Scardamalia & Bereiter, 1994), engage and learn together in affinity spaces (Gee & Hayes, 2011), and distribute information and knowledge throughout a larger sociotechnical system (Hutchins, 1995). In online gaming communities, novice learners can come together to increase their knowledge by working with other highly skilled players. Online gaming discussion forums themselves allow for knowledge generation of how to solve complex problems in virtual worlds, such as how to conquer an in-game boss battle, determine the most efficient equipment, and figure out solutions and strategies for optimum play. Online collaborations can serve to foster the zone of proximal development among novice and expert players, that is the difference between what a learner can do on their own compared to what a learner can do with guidance and support from others (Vygotsky, 1978).

The most prominent example of scientific practice in discussion forums around gaming is Steinkuehler and Duncan's (2008) study of scientific habits of mind and disposition in online discussions of the massively multiplayer online (MMO) game of *World of Warcraft* (WoW). Using Chinn and Malhotra's (2002) theoretical framework for evaluating inquiry tasks and Kuhn's (1992) framework for epistemology, they noted that 86% of random forum discussions (nearly 2,000 posts) focused on social knowledge construction and 65% of evaluative epistemology in which knowledge is treated as open and evaluative. Practices such as peer-review, collaboration, data sharing, argument generation and counterargument, and the use of evidence to warrant one's claims took place in these forums. Many of these discussions took on similar activities to how professional scientists share data, challenge each other's interpretations of evidence, and confirm claims through their own peer review system. While Steinkuehler and Duncan's (2008) evaluation of WoW demonstrates clear empirical evidence of scientific practice in discussion forums, we need deeper dives into how players use and integrate scientific practices to *collaborate together*. Steinkuehler and Duncan note that while some may believe that these gaming discussion environments allow a large number of posters to make one to two contributions, the WoW online communities solve problems together as large groups of thinkers. In the case of *Pokémon GO*, large collaborative efforts exist because the game (like many games) is not very transparent in its mechanics. As such, misinformation can occur due to "trolling" (when players intentionally post deceptive information) and speculations mistakenly being conveyed as accurate information. Additionally, because of the location-based nature of game overlaying the virtual world over the real world, people are much more likely to collaborate in various scientizing projects as data collection typically requires efforts beyond what a single or a few players can offer. We are interested in understanding how players collaborate together in scientific practice to develop deeper understanding of the game in organized distributed efforts. Finally, we are interested in understanding the shift from desktop gaming towards mobile gaming, and how learners also use their own locations and contexts to solve specific needs and questions.

Theoretical Frameworks

We use the concept of scientizing (Clegg & Kolodner, 2014) to explain how and why people use science inquiry practices in their everyday live. Scientizing is often not the norm of science education in young people's lives. However, it is an important concept to encourage people to pursue science learning. When young people scientize, they take on new roles in science learning and feel empowered to use science practices to improve their world. Scientizing focuses on the development of scientific dispositions. First, conceptual and procedural understanding focuses on how people understand scientific concepts and principles. In other words, how people know when to use science practices, why they use them, and how science is used in practice. Interest refers to people's desires and personal reasons to engage with science practices. Social interactions refer to people's engagements in science practice together. Finally, personal connections emphasize connecting science disciplinary practices to their own knowledge and value systems. We are using the scientizing framework because we are trying to understand the roles of scientific practices that come out of everyday practices of playing *Pokémon GO* and how these practices are driven by participants' interest, curiosity, and social relationships, rather than in formalized academic settings.

To understand the scientizing practices of *Pokémon GO* players in online discussion forums, we use Chinn and Malhotra's (2002) complex science inquiry framework. *Authentic scientific inquiry* refers to the complex activity and research that scientists carry out. Example processes include scientists generating their own research questions, selecting and even inventing variables to investigate, creating complex procedures to address questions of interest, devising models to address research questions, employing multiple controls, incorporating multiple measures of different variables, judging against bias, constantly questioning whether their results are accurate and correct, employing multiple forms of argument, and constructing theories and resolving inconsistencies. In contrast, *simple inquiry tasks* attempt to capture the core process of scientific practices, but are mostly basic processes. For instance, in a simple experiment, learners are usually looking at a single independent variable and single dependent variable. In simple observations, learners carefully observe, measure, and describe objects and phenomenon. For simple illustrations, learners might follow step-by-step a specified procedure and observe the outcome. Authentic and simple inquiry tasks are extreme ends of a spectrum. For this study, we are using Chinn and Malhotra's authentic and simple scientific inquiry to examine how players of *Pokémon GO* engage in these practices as they pursue their interests in online discussion forums.

Methods

We adhered to the standards of a comparative case study (Merriam, 2009) to examine three exploratory cases of scientizing in online discussion about *Pokémon GO*. We used ethnographic research methods (Guba & Lincoln, 2005) to conduct a content analysis of the online forums. We took an emic perspective for this research (Guba & Lincoln, 2005); to understand *Pokémon GO* players, we joined and participated in *Pokémon GO* online groups and also actively played the game ourselves. In the third week of July 2016 of the release of *Pokémon GO*, the second author of this paper joined 215 online social media groups, Facebook, and Reddit forums. At the time of joining, each of these groups had between 500 and 15,000 members. To spread ourselves out evenly across the groups, we picked groups for each of the 25 most populous USA cities and focused on at least two cities per USA state. We also joined special focus *Pokémon GO* groups (e.g. New England, Disneyland). Once we joined and participated, we monitored the online feed in aggregate from July to October 2016. During this time, we observed and recorded 1) general content and types (topics) of posts; 2) very active posts; 3) themes of the posts; 4) behaviors of the discussants; 5) special events; and 6) collaborative projects about the game. To capture the data, we took notes of these observations and screenshots of the types of topics and significant events. We wrote up field notes that aggregated all the observations and screenshots around a set of user-generated projects and activities (e.g., mapping, egg hatching, determining statistics).

To build the exploratory case studies around the scientizing practices of the *Pokémon GO* online discussants, we set up a criterion for selection. Based on Chinn and Malhotra's (2002) scientific inquiry framework, we chose comparative cases that demonstrated varied scientizing practices, such as hypothesis testing, checking against anomalous data, and social construction of knowledge. We chose three online collaborative projects as cases (July to September 2016) from *The Silph Road*, a large public grassroots network of *Pokémon GO* players with an emphasis on researching various aspects of the gameplay, as they were often cited in many of the *Pokémon GO* communities. *The Sliph Road* is a Reddit subgroup of *Pokémon GO* players focused on creating an in-person community network. There are at least nine core team members, with thousands of contributors. They engage the *Pokémon GO* player base to crowdsource large amounts of data to answer questions about game mechanics and other aspects of play. Typically, these projects result from questions or information gaps that developer *Niantic* has not commented on. Once we selected these three focal cases for review, the first and second author coded the observations and screenshots using Chinn and Malhotra's framework. Example codes included cognitive processes (i.e., generating research questions, designing studies, selecting variables, planning procedures, controlling variables, planning measures, making observations, transforming observations, finding flaws, generalizations, types of reasoning, developing theories, coordinating results from multiple studies, and studying research reports) and dimensions of epistemology (i.e., purpose of research, theory-data coordination, theory ladenness of methods, responses to anomalous data, nature of reasoning, and social construction of knowledge). From these codes, we determined whether they were examples of authentic inquiry, simple inquiry, or mixed. After the coding process, we discussed and resolved issues and created narratives that are reflective of the players and the online discussion around *Pokémon GO*.

Findings

We present three comparative case studies of players engaging in discussions around *Pokémon GO*. For each case study, we provide a description of the case and an analysis of the scientific inquiry practices.

Case 1: Crowdsourcing to Compare Multiple Data Sets to Find Glitches

Some players in *The Sliph Road* suspected that there was a glitch present in the game for the first few months after launch regarding the calculated metric unique to each individual Pokémon called the "Individual Value". Individual Value (IV) is an aggregate score of statistics that pertain to unique Pokémon and is a ratio of the sum of three hidden attributes of each individual Pokémon to the maximum value possible for those attributes. The three hidden scores for each Pokémon are its "attack" score (ATT), "defense" score (DEF), and "stamina" score (STA)(1). The value for each of these three scores for any given Pokémon is an integer between 0 to 15. The sum of these scores, divided by the maximum possible aggregate score (45) is the ratio that is referred to as IV-Individual Value, and it is always expressed as a percentage. The IV can also be expressed with the following equation: $IV = (ATT + DEF + STA) / 45 * 100$. For advanced *Pokémon GO* players, IV are an important "hidden" measure of Pokémon strength in battle.

The Silph Road, along with players contributing data, organized and conducted their own research to confirm the suspected glitch was indeed real. This glitch speculation emerged at first from anecdotes from players, with many people complaining in online forums that some Pokémon rarely had a high attack value and others almost always had a very high attack value. This seemed to be correlated, they claimed, with the "Pokédex Number" of each Pokémon(2). The Pokédex Number of a Pokémon is simply that creature's permanent index number. For instance, the Pokédex Number for Bulbasaur is 1, for Ivysaur it is 2, and this goes up to 149 in the current version of *Pokémon GO*, as of November 18, 2016. Community contributors to *The Silph Road* decided to collect data on the IV numbers for caught Pokémon, as well as the attack attribute, to engage in hypothesis testing to see if the anecdote held in the face of an empirical test. Nine main participants led the design, management, and data analysis for the project. This group organized and collected data on July 23rd, 2016 from 4,120 "throws" (throwing a Pokéball is an attempt to capture the Pokémon).

Analysis of scientizing practices. In this project, several aspects of scientizing and inquiry practices exist. First, the group attempted to figure out how anomalous data could have occurred. The hypothesis test was generated because *The Silph Road* could not get direct answers from the developers. The first null hypothesis generated from *The Silph Road* occurred from the initial suspicion of the glitches occurring in the Individual Value of *Pokémon* monsters. The null stated that Pokédex Number is not related to IV. However, the group collected enough data and rejected the null hypothesis (Figure 1 – left). A second hypothesis test was done to compare the results with the first test. The data after Sept 22nd (Figure 1 – right) demonstrated no correlation between IV and Attack; the group here assumed the glitch was fixed in a new update. In both cases, two sets of data and interpretation provided very stark results. Chinn and Malhotra's (2002) notes that simple inquiry tasks are too straightforward, and that responses to anomalous data are to change the hypothesis. However, in authentic scientific research, there are different responses to anomalous data. In this case, *The Silph Road* group determined that the anomalous data could explain that a glitch was involved on July 23, 2016, but not on September 22, 2016. The group did not change their hypothesis, but rather assumed there was a more plausible explanation of a glitch in the game. Being able to compare data from two different dates shows an epistemology that considers results as dynamic. Here, like scientists, the group had to coordinate results from multiple studies, particularly with data that conflicted with each other. However, this group only coordinated results on one level of analysis (IV vs. Pokémon identification number). The group did construct their own theoretical explanations, starting with anecdotal observations that were confirmed by evidence between multiple studies.

A second form of scientizing practices that exists is transforming observations. In authentic scientific practices, these observations are often repeatedly transformed into multiple data formats. In simple inquiry tasks, observations are seldom transformed into other data formats, except perhaps straightforward graphs. In this case study, we observed simple XY graphs developed to compare the two hypotheses. Figure 1 are graphs of Individual Value of a Pokémon and their species identification number. While the figures are the same straightforward XY graphs, the case study shows evidence of the group highlighting important aspects of the graphs. The group used large samples of data (Figure 1, N = 250 left; N = 341 right) to reduce the amount of sampling error in the data. As well, the shapes of the distribution (Figure 1, curvilinear distribution in left and randomized distribution on right) demonstrate the use of visualization of the large amount of data gathered by the players for interpretation.

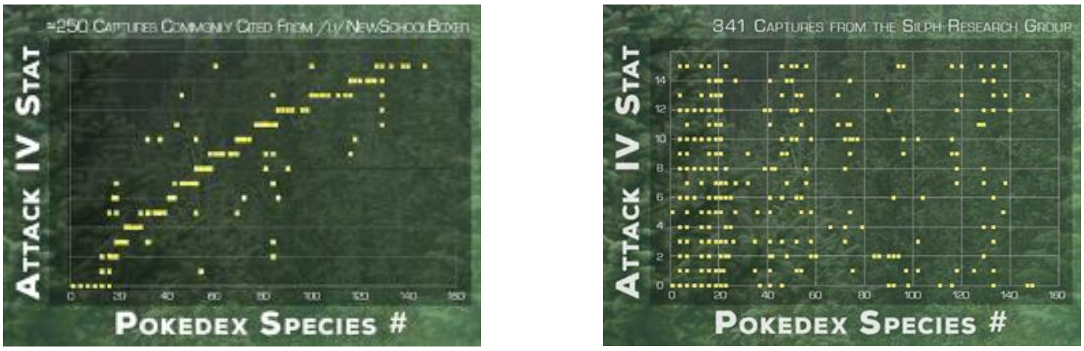

Figure 1. The left figure shows one set of results during the "High IV Glitch Phase", from The Silph Road[3]. The right figure shows "post-glitch" testing of Pokémon attack IV values[3].

Case 2: Crowdsourcing to Combat Misinformation

Another major data collection activity coordinated by *The Silph Road* was the "Egg Hatching" research project. Shortly after the game launched, there was a tremendous amount of confusion and misinformation surrounding the nature of a game feature called *egg hatching*. In *Pokémon GO*, players can find eggs by visiting PokéStops. The eggs found at PokéStops can be incubated and hatched if a player walks far enough in the real world, and a Pokémon will emerge from the egg. A key point of confusion about the game centered on the type of Pokémon that could be hatched from these eggs. Players were uncertain as to whether "regionally locked" Pokémon could hatch from eggs, and intentional misinformation about the subject were rampant. There are four "regionally locked" Pokémon that exist in the game, meaning they can each be caught only on one specific continent: Kangaskhan can only be caught in Australia or New Zealand, Mr. Mime in Europe, Tauros in North America, and Farfetch'd in Asia. The burning question that the *Pokémon GO* community had was "can regionally locked Pokémon hatch from eggs outside of the region in which they appear"? Until September 22, 2016 Niantic had not made a formal statement about this matter.

This particular question became very contentious as "spoofer" accounts began to appear across the world. In ARGs, a "spoofer" is a person that uses software tools to falsify their physical location in the game, and are thus able to make it appear as if they are in another location. Not long after the launch of the game, regionally locked Pokémon began appearing in Gyms and play areas associated with accounts suspected of spoofing. In online communities, some people publicly admitted to spoofing to acquire regionally locked Pokémon from other continents without having to travel there. The area of uncertainty and contention that caused most of the controversy centered on the fact many players claimed they acquired regionally locked Pokémon from eggs that they hatched. In some cases, it appeared that players making the claims believed it was possible, and simply used this belief to obfuscate their cheating. Other players seemed to be intentionally spreading misinformation and "trolling" the *Pokémon GO* community. Between July 15th to September 30th, 2016, our research team monitored over 200 *Pokémon GO* community Facebook pages, and claims of hatching regionally locked Pokémon generated long and contentious arguments in at least half of them, with some players simply believing the poster and congratulating them for hatching the region-locked Pokémon outside of the specified region, and others accusing them of spoofing. The social conflict surrounding this issue was high, with many players feeling angry that members of their community were cheating to "get ahead". This prompted *The Silph Road* to conduct a large crowdsourced research project to determine whether or not Pokémon from other regions could in fact be hatched from eggs[4]. The effort was organized on *The Silph Road Reddit* and was a contributory data collection project, where users provided their "total number of eggs hatched and total number of foreign region locked Pokémon"[4]. The data were provided in a structured way in the forum thread. Thousands of contributors provided data on their egg hatches, and after data collection, players had hatched in aggregate 40,507 Pokémon eggs. Zero eggs produced a region locked Pokémon from a different continent. Thus, the project organizers declared the myth "busted".

Analysis of scientizing practices. This case study demonstrates many themes of scientizing practices to counter against misinformation. Unlike WoW studies from Steinkuehler and Duncan (2008), we observed that players needed to navigate complex misinformation. To find the answer to their question of region specific Pokémon hatching from eggs, the group needed to guard against bias. Authentic science practices make an attempt to limit experimenter bias. To reduce errors and sampling problems, the group had to collect data characterized as 1) large in amount (40,507 Pokémon eggs); 2) varied from thousands of random players; and 3) varied in regions around the world (all playable continents). Here, the players worked together to make sure threats against validity were mitigated. Second, the players had to check data against misinformation and anomalous data. Because misinformation may have persisted from spoofers, the players in *The Silph Road* needed to constantly check their data against possible spurious claims. Here, the players' epistemology focused on theory-data coordination. Chinn and Malhotra (2002) note that in authentic inquiry, scientists coordinate theoretical models with multiple sets of complex, partially conflicting data. In simple inquiry, people coordinate one set of observable results with conclusion about those observable results. In this case, we believe the theory-data coordination leans more toward authentic than simple. Because *The Silph Road* collected thousands of data points from all across the world, they were comparing multiple sets of data. In this case, the players were seeking global consistency, rather than local consistency. Because the players were committed to seeking confirmation of their theory, they had to respond to anomalous data by rationally discounting data. By having a large global dataset, this helped to eliminate biased data and misinformation.

Case 3: Crowdsourcing to Create Knowledge Together

The largest class of crowdsourced and community sourced data collection that has occurred and continues to occur among the *Pokémon GO* player base is the development of "nest maps". In *Pokémon GO,* certain locations in the world tend to produce a specific type of uncommon Pokémon at a relatively high frequency, referred to as nests(6). These nest areas are particularly useful for players because they produce a specific Pokémon in relative abundance (approximately 3 to 15 Pokémon per hour), and players will travel to that location for the certainty of acquiring the resident Pokémon. Mapping the locations of these nests and the Pokémon that inhabit them, has become a large and persistent project for *Pokémon GO* players that want to contribute data to the community. Adding to the complexity of the project and the need for continuous community sourced data collection is the fact that nests change over time. Nests appear to persist for approximately one month and then they change, in what the *Pokémon GO* player community has come to call "nest migration". As such, player generated nest maps are in constant need of revision. *The Silph Road* manages the largest nest mapping project, though an interesting phenomenon occurring is that many local communities are building regional projects to map and communicate nests in their own area. Typically, an organizer for a community will create a document or spreadsheet, and solicit suspected nest locations from the local players, who then update the list directly, or post reports into an online forum thread. Examples include the San Antonio nest map(7), which is updated by the organizer monthly using the local Facebook group[6], and the Las Vegas Pokémon Nest spreadsheet, which collects data on nest from community members, and distributes a link to a Google Docs™ spreadsheet reporting 293 nests in and near Las Vegas. The largest effort to map global nests remains with *The Silph Road*, which has developed the contributor capacity to very quickly collect a lot of data after each migration(8). For instance, the third Pokémon migration occurred on September 26th, 2016. Within 24 hours of the migration, *The Silph Road* reported 70,374 individual nest reports submitted by players worldwide, mapping 57,606 unique nest locations and corresponding Pokémon(9).

Analysis of scientizing practices. This case study demonstrates aspects of the *social construction of knowledge* epistemology. Chinn and Malhotra (2002) explain that scientists construct knowledge in collaborative groups, often building on prior research from other scientists. To do this, scientists need institutional norms, such as a peer-review process or models of research. In the simple inquiry perspective, students can construct knowledge together too, but they seldom build on prior research or have experience with institutional norms. In this case, *The Silph Road* created a way for the community to contribute towards building this knowledge that is somewhere between authentic and simple. The creation of Google Docs, social media, and mapping tools provided a common way for everyone in *The Silph Road* to contribute. Here, there is a grounding of the methods which creates a guideline for the group to report the data for the nesting project. However, there are no institutional norms in the group for patterns of argument or a model for research in this case. For instance, the group does not (yet) have a way to review arguments about the nest migration.

Discussion and Implications

Steinkuehler and Duncan (2008) provided clear empirical evidence to show that players engaged in WoW online communities not only engaged in informal science literacy, but that an overwhelming majority of the conversation was dedicated to productive forms of scientific practice. Similarly, our findings demonstrate that players engaging in *Pokémon GO* online communities are not only engaging in scientific practice, but aspects of these practices fall within aspects of authentic scientific practice. Our findings extend the work of Steinkuehler and Duncan by showing specifically how these scientizing practices emerge to solve very complex problems. The nature of the problems in *Pokémon GO* require distributed collaboration across time and space through ICT (Hutchins, 1995). Determining "glitches", filtering through misinformation, and creating a knowledge base for geo-mapping is not an effort that only a small handful of experts could solve. Our findings show that crowdsourcing information and data together to solve problems not only encourages scientizing practices, but *requires those practices to be collaborative*. Players had to collect large amounts of data in multiple forms, organize that data collection effort across multiple continents and locations, generate models from that data, create community practices around how that data is to be managed, create evidence-based arguments, and determine the unknowns within their arguments. We believe that even though *Pokémon GO* touts itself as a simple online location-based ARG, there are deeper scientizing practices that can occur within everyday gameplay. In addition to the mass appeal, abundant opportunities for participation in data collection and sharing, as well as the need for communicating and working together as a group make *Pokémon GO* an attractive venue for engaging people in scientizing practices.

Furthermore, we believe that the implications of our research for informal science learning are meaningful for families and children — *Pokémon GO* can be used to motivate scientizing practices in families and children. *Pokémon GO* is a mainstream game meant for players of all ages, with very close youth and family connections. Sobel et al. (2017) found that many parents had a much more positive attitude towards the screen time their children were having while playing a game like *Pokémon GO* than other video games (such as *Minecraft*) since they are playing outside and together as a family. With the added benefit of strong appeal to parents, we believe a game like *Pokémon GO* presents an ideal opportunity for engaging children to scientize together with their friends and family. Takeuchi and Stevens (2011) note that children's engagement with parents about digital media has shown great potential for learning. As well, children scientizing together with other adults has shown great potential for engagement in science learning (e.g., Bell, Bricker, Reeve, Zimmerman, & Tzou, 2013). In our future work, we plan to look at how families and children may be engaging in scientizing practices in other online gaming communities, similar to *Pokémon GO*. Our findings are limited at this point because we were unable to dig deeper at the ages and relationships of the players in these online venues. Future work in this area needs to uncover more specifics about whether youth and families are currently engaging in these crowdsourcing scientizing efforts. We believe that if youth and families are not engaged in these practices around their commercial games, online communities can potentially be developed for this purpose. Online communities like Reddit and Facebook are not designed yet for family, teacher, and children crowdsourcing projects for scientizing. However, families, children, and other learning stakeholders could either participate or run these kinds of large-scale investigations themselves. We believe that bridging third spaces (Steinkuehler, 2008) by creating online communities for families, children, and teachers around *Pokémon GO* and other simple location-based games could potentially be useful in demonstrating how everyday practices and engagements can contribute towards authentic science inquiry practices.

Endnotes

(1) https://pokeassistant.com/main/ivcalculator
(2) http://www.pokemon.com/us/pokedex/
(3) https://thesilphroad.com/science/attack-iv-pokedex-number-correlation
(4) https://www.reddit.com/r/TheSilphRoad/comments/4w9d00/have_you_hatched_eggs_great_i_want_you_to_tell_me/
(5) http://heavy.com/games/2016/09/pokemon-go-can-you-hatch-region-specific-pokemon-from-egg-eggs-outside-of-location-tauros-kangaskhan-mr-mime-farfetchd-north-america-europe-asia-australia-john-hanke/
(6) https://pokemongo.gamepress.gg/pokemon-nests
(7) https://docs.google.com/document/d/1a7kzD3ewFCS68yEEV55gUWtsE011lS3VtUZlBqBZokw/edit
(8) https://www.reddit.com/r/TheSilphRoad/comments/54ndqm/megathread_the_3rd_great_migration_appears_to/
(9) https://thesilphroad.com/atlas

References

Asbell-Clarke, J., Edwards, T., Rowe, E., Larsen, J., Sylvan, E., & Hewitt, J. (2012). Martian Boneyards: Scientific inquiry in an MMO game. *International Journal of Game-Based Learning (IJGBL)*, *2*(1), 52–76.

Azevedo, F. S. (2013). The tailored practice of hobbies and its implication for the design of interest-driven learning environments. *Journal of the Learning Sciences*, *22*(3), 462–510.
Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development*, *53*(1), 86–107.
Bell, P., Bricker, L.A., Reeve, S., Zimmerman, H.T., & Tzou, C. (2012). Discovering and supporting successful learning pathways of youth in and out of school: Accounting for the development of everyday expertise across settings. In B. Bevan, P. Bell, R. Stevens, & A. Razfar (Eds.), *LOST opportunities: Learning in out of school time* (pp. 119–140). London: Springer.
Chinn, C. A., & Malhotra, B. A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education*, *86*(2), 175–218.
Clegg, T. L., & Kolodner, J. (2014). Scientizing and cooking: Helping middle-school learners develop scientific dispositions. *Science Education*, *98*(1), 36–63. https://doi.org/10.1002/sce.21083
Edelson, D. C., & Joseph, D. M. (2004). The interest-driven learning design framework: motivating learning through usefulness. In *Proceedings of the 6th International Conference of the Learning Sciences* (pp. 166–173). International Society of the Learning Sciences.
Falk, J., & Davenport, G. (2004). Live role-playing games: Implications for pervasive gaming. In *International Conference on Entertainment Computing* (pp. 127–138). Springer.
Gee, J. P., & Hayes, E. (2011). Nurturing affinity spaces and game-based learning. In C. Steinkuehler, K. Squire, & S. Barab (Eds.), *Games, learning, and society: Learning and meaning in the digital age* (pp. 129–153). New York, NY: Cambridge University Press.
Guba, E. G., & Lincoln, Y. S. (2005). Paradigmatic controversies, contradictions, and emerging confluences. In *The SAGE handbook of qualitative research* (3rd ed., pp. 191–215). Thousand Oaks, CA: SAGE.
Hutchins, E. (1995). How a cockpit remembers its speeds. *Cognitive Science*, *19*(3), 265–288.
Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., … Watkins, S. C. (2013). *Connected learning: An agenda for research and design*. Digital Media and Learning Research Hub.
Ketelhut, D. J. (2007). The impact of student self-efficacy on scientific inquiry skills: An exploratory investigation in River City, a multi-user virtual environment. *Journal of Science Education and Technology*, *16*(1), 99–111.
Lee, O., & Fradd, S. H. (1998). Science for all, including students from non-English language backgrounds. *Educational Researcher*, *27*(4), 12–21.
Kuhn, D. (1992) Thinking as argument. *Harvard Education Review*, *62*(2), 155–178
Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: John Wiley and Sons.
Rashid, O., Mullins, I., Coulton, P., & Edwards, R. (2006). Extending cyberspace: Location based games using cellular phones. *Computers in Entertainment (CIE)*, *4*(1), 4.
Rutherford, F. J., & Ahlgren, A. (1990). *Science for all Americans*. Oxford University Press.
Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of the Learning Sciences*, *3*(3), 265–283.
Sobel, K., Bhattacharya, A., Hiniker, A., Lee, J.H., Kientz, J., & Yip, J.C. (2017). “It wasn't really about the Pokémon": Understanding families' experiences with a location-based mobile game. In *Proceedings of SIGCHI Human Factors in Computing Systems (CHI 2017)*. New York, NY: ACM.
Steinkuehler, C.A. (2008) Cognition and literacy in massively multiplayer online games. In J., Coiro, M. Knobel, C. Lankshear, D. Leu (eds.) *Handbook of research on new literacies.* (pp. 611-634). Erlbaum, Mahwah NJ.
Steinkuehler, C., & Duncan, S. (2008). Scientific habits of mind in virtual worlds. *Journal of Science Education and Technology*, *17*(6), 530–543.
Takeuchi, L., & Stevens, R. (2011). *The new coviewing: Designing for learning through joint media engagement*. New York: Joan Ganz Cooney Center at Sesame Workshop. Retrieved from http://www.joanganzcooneycenter.org/publication/the-new-coviewing-designing-for-learning-through-joint-media-engagement/
Vygotsky, L. S. (1978). Interaction between learning and development. In *Mind in society: The development of higher psychological processes* (pp. 79–91). USA.

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