Crowdsourcing citizen science: exploring the tensions between paid professionals and users

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Abstract

This paper explores the relationship between paid labour and users within the Zooniverse, a crowdsourced citizen science platform. The user activities involve the collective categorisation of large datasets, mainly relating to images that cannot currently be analysed algorithmically. However, unlike other examples of micro-tasking, there is also the possibility for individual users to make serendipitous discoveries. It was initially established by a small group of academics for a single astronomy project, but has now grown into a multi-project platform that has engaged over 1.3 million users so far. The growth has introduced different dynamics to the platform as it has incorporated a greater number of scientists, developers, links with organisations, and funding arrangements. The different organisations and funding requirements each bring additional pressures and complications. The scientists come from a research-led university context, while the developers are drawn from more of a start-up culture with an emphasis on open-source ideals. The relationships between paid/professional and unpaid/citizen labour have become increasingly complicated with the rapid expansion of the Zooniverse. The paper draws on empirical data from an ongoing research project that has access to both users and paid professionals on the platform. This combination of ethnography, in-depth interviews, and quantitative data combines to provide new insights into the organisation and processes of this large citizen science platform. The Zooniverse case study provides an important starting point for understanding the dynamics of paid and unpaid work in the context of peer production. There is the potential through growing peer-to-peer capacity that the boundaries between professional and citizen scientists can become significantly blurred. Crowdsourcing can allow the complex tasks involved in data analysis to be collectively achieved, yet there remain limits to the contribution that individuals in the crowd can make. The findings of the paper therefore address important questions about the production of value, ownerships, and the politics of open source acts. These are considered specifically from the viewpoint of the users and therefore form a new contribution to the theoretical understanding of crowdsourcing in practice.

1. Introduction

The Zooniverse is a citizen science crowdsourcing platform. It began as a single astronomy project to find a new way to analyse a large dataset of pictures of galaxies, but has since grown to over fifty projects. The projects involve categorising data, often pictures, but this has also expanded to videos and audio. For example, Galaxy Zoo involves categorising pictures of galaxies. In a new iteration of the project, Galaxy Zoo Bar Lengths, the user is presented with a picture of a galaxy and asked "Does this galaxy have a bar?" followed by a yes/no option with further branches of questions (Zooniverse, 2015). Along with this basic

task - something that could be compared to the activities on micro-work platforms - are two other important factors. The first is the chance of serendipitous discoveries. Unlike micro-work, there is also the possibility to contribute to something beyond the scope of the assigned individual task. This could involve contributing to the process of discovery in a substantive way or even an individual user discovering something themselves. This potentiality is tied to the ethos of Citizen Science. This involves, either partly or wholly, the involvement of non-professionals in science. However, within this definition there are two important divisions to consider for the role of non-professionals. Firstly, it can just mean the involvement of non-professionals in the processes of data gathering, analysis, and interpretation. Secondly, it can mean non-professionals becoming genuinely involved in decision making processes about science (Lewenstein, 2004: 1). These two divergent positions capture the complexities of citizen science in practice. The Zooniverse provides the potential for large numbers of users to engage in the first, while offering the potential for the second. It is not necessary to offer the second to achieve the first, however the use of the term citizen science at least implies some dimension of the second. This paper aims to explore the contradictions that emerge in practice between the two, especially considering the tensions between paid and unpaid labour.

The infrastructure that allows very large numbers of users to participate simultaneously in the Zooniverse is run on Amazon Web Services cloud servers. Amazon also runs the Amazon Mechanical Turk on this service. This involves splitting larger tasks into small fragments and then outsourcing them to a pool of digital workers. The way in which the labour input becomes hidden on these kinds of platforms has been described by Trebor Scholz (2015) as 'digital black box labor.' It obfuscates a number of issues: how is the labour process organised and who is doing it? How is it managed and controlled? What is it being used for? And, particularly important for this paper, what tensions are present both inside and beyond the platform? Therefore, the paper takes a lead from Karl Marx's (1976: 279) metaphorical tailing of 'Mr. Moneybags' and 'the possessor of labour-power' into the 'hidden abode of production.' However, in this case the focus is not the production per se, but into the obscured processes of digital black box labour: the hidden abode of crowdsourcing.

The challenge of this paper is therefore to focus the analysis on the users in the Zooniverse. This begins with a review of the relevant literature on crowdsourcing, drawing attention to the key conceptual issues shared across platforms. The next part of the paper discusses the threefold methodological approach deployed in the investigation: interviews with both paid workers and users involved in the Zooniverse and an ethnography from the user perspective. Before moving on to examine the empirical findings, the background of the Zooniverse is explored. This involves an analysis of the platform's development, covering the influences of research culture and the university, the culture of computer programmers, and the impact of funding. The findings of the research are presented in the following section, focusing on the classifying process and then the user perspective. The key argument of this paper is that by drawing attention to the users it is possible to explore the tensions and contradictions inherent in a citizen science crowdsourcing platform.

2. Crowdsourcing platforms

The term crowdsourcing was first coined by Howe in 2006. He stated that it was 'the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open Call.' While Howe's definition was useful in its early stages, the breadth of crowdsourcing applications in the profit and not-for-profit arena has now breached this founding definition (Estelles-Arolas et al., 2012). Kaganer (2013: 23) more recently describes crowdsourcing as 'a third generation sourcing ecosystem' and argues that new organised online intermediaries offer a pool of virtual workers tempting for any potential buyer. Kaganer's description is more attuned with a traditional market-based value chain understanding of labour transactions, albeit in the global marketplace. For many researchers, crowdsourcing has the potential to provide a new source of productivity, innovation, and knowledge capture (Andriole, 2010; Lindic et al., 2011) with its only down sides being intellectual property (IP) leakage, a lack of trust in the crowd due to its amorphous anonymity (Knudensen and Mortensen, 2011), and a low propensity to deal with highly complex, larger projects in a cost effective way. However, value can be realised when contemporary businesses can cost effectively match different types of crowds with unique organisational needs (Erickson et al., 2012). For example, many contemporary organisations require a wide variety of micro-tasks to be carried out including tasks that need a variety of skills, knowledges, cognitive strategies, experiences, problem-solving abilities, and/or a combination of all these on a daily basis. Chui et al. (2012) therefore emphasise that the value creation of crowdsourcing is determined by the collaboration within and across an enterprise and its ability to match a micro-task with an individual suitable to carry it out.

The basic process of labour crowdsourcing is encapsulated in micro-work. For Amazon Mechanical Turk this involves breaking a larger project down into small discrete tasks, or what Amazon terms HITs (Human Intelligence Tasks). The interaction – or labour process – is comparable at this point, with isolated individuals each contributing to a larger overall project. The name of the platform is inspired by the historical Mechanical Turk (or Automaton Chess Player), a hoax from the 18th Century. While 'the historical Turk showed off technology to draw attention away from the human laborer, today, Mechanical Turk's . . . crowd sorcerers work with coolness and the spectacle of innovation to conceal the worker' (Scholz, 2015). It is in this way that crowdsourcing platforms are similar to a 'black box.' This has a dual meaning, referring to the safety recording device found in transportation or to 'a system whose workings are mysterious; we can observe its inputs and outputs, but we cannot tell how one becomes the other' (Pasquale, 2015: 3). Scholz (2015) develops this term into 'digital black box labor' to capture this process on crowdsourcing platforms. As Scholz (2015) continues to argue that 'many researchers have focused on optimizing . . . these platform ecosystems: trying to make them run more efficiently, more frictionless and with a better understanding of the motivations of the workers.' However, the more pressing task for researchers is to focus on the 'building of alternatives, outrage, conflict, and worker organization.'

This micro-tasking is common across for-profit crowdsourcing of labour and not-for-profit approaches. As Smith et al. (2013) have argued, the difference is that citizen scientist users

are motivated a different way. They tend to take a sense of pride and enjoyment in their activities on the platform, a factor that can lead to the formation of a dedicated crowd with high quality outputs. This aspect does not mean that citizen scientists can be mobilised simply through their desire to take part in science. There is a risk that these kind of users may feel their contributions (which are often the result of hard work) are not being valued and perhaps even exploited (Shahri et al., 2014). The combinations of the two dimensions of citizen science, as discussed earlier by Lewenstein (2004: 1), therefore require a balance. From the perspective of the platform, both motivation and loyalty need to be encouraged. Therefore, most crowdsourcing platforms of this type promote their utilitarian purpose in order to maintain organisation of the crowd and the users' collective contributions (Chamberlain et al., 2013). In the context of a not-for-profit system, this is a complex endeavour without the recourse to monetary incentives.

While motivation is important, there are other important distinctions to be made across crowdsourcing platforms. Crowdsourcing can be conceptualised into two different types: lead user innovation and micro-work. These can be differentiated in terms of quantitative and qualitative outputs. The quantitative output is associated with microwork platforms like Amazon Mechanical Turk, while the qualitative output is closer to those involving lead user innovation, found with the competition type model (For example, see: Stinson, 2014). The quantitative model involves limited user outputs. Microwork 'relies on dyadic relationships consisting of one buyer, one supplier and a well defined final deliverable' (Kaganer et al., 2013: 25). The larger projects are fractured into small parts and then the costs are subsequently driven down through internal competition. There is no opportunity for collaboration and innovation is not possible, nor is it incentivised. The qualitative model, on the other hand, involves a problem being tendered out to a crowd with the aim of soliciting solutions. It is a process in which expertise can be sourced from within a crowd. The first method to do this is the 'broadcast search' with an open call for ideas or solutions (Jeppesen and Lakhani, 2010). The second is the formal organising of outsourced innovation. In this 'arbitrator model', found with crowdSPRING or InnoCentive, organisations can gain 'on-demand access to a specialized community of skilled suppliers who can be engaged on a project via a competition or contest' (Kaganer et al., 2013: 26). The quantitative and qualitative models are both driven by outputs, requiring problems that are identified beforehand, but differ in the level of engagement of the crowd, collectively or otherwise.

There are strengths and weaknesses with either of these types, yet the Zooniverse combines both as a hybrid model. While the Zooniverse shares the quantitative micro-work features in the analysis of scientific data, it also offers the potential – and it is important to stress that this is a potential – to contribute more broadly as citizen scientists to qualitative scientific discoveries. The main way in which this manifests itself on the platform is through serendipitous scientific discovery. One example of this is the discovery of Hanny's Voorwerp. This new phenomenon was named after a Dutch schoolteacher who identified the object while categorising on the Zooniverse (Lintott et al., 2009). There is also considerable excitement about the possibilities of new discoveries on the project Higgs Hunter, Planet Hunter, and Snapshot Supernova. However, there is a formal distinction between the platform and the scientists on the one hand and the crowd of users on the other. There is an explicit public engagement aim to the Zooniverse, achieved by allowing users to engage in

scientific analysis but also providing outreach and educational opportunities. However, the question of whether this process goes beyond a unidirectional relationship is less clear. This requires an understanding of how the heterogeneous public respond with their own ideas and demands. This paper therefore seeks to explore the intricacies associated with co-creation and peer production between the citizen scientist and the traditional scientist when both micro-tasking and serendipitous discovery occur on an online citizen science platform. In particular, the study focuses on the 'digital black box of labor' and the hidden aspects of crowdsourcing on a citizen science platform.

3. Method

This paper combines three different empirical sources in order to investigate the Zooniverse. To understand the specificities of the labour process and the relationship between paid labour and users within the platform, qualitative methods were used to gather data which has been analysed using an interpretivist approach (Walsham, 1995). The first method is a set of 23 in-depth interviews with paid employees of the Zooniverse. They cover all of the different roles involved on the platform, including both founding members and newer staff. These interviews were arranged through a collaboration with the Zooniverse and were conducted in person in Oxford and Chicago. The second empirical component involved 19 interviews with users. These were selected at random from a sample of users who agreed to be interviewed after a survey. Given the geographic spread of the users, the interviews were conducted on Skype. Both sets of interviews were transcribed and these were analysed with the NVivo software package.

The third part of the research is an ethnography conducted by a post-doctoral research assistant. Her online practices were informed by Baym's (2006) ethnographic approach. This entails participation as a means to understand important aspects of social life, in this case the life of an on citizen science contributor. The ethnography of the Zooniverse was carried out over a year, including classifications and engagement in the online community. The researcher kept a diary on a near daily basis, which when transcribed, was converted into approximately 80,000 words of thick description. This was accompanied by screenshots that provide valuable insights into the user perspective across different projects and activities. The ethnography was focused on two projects, Galaxy Zoo (as the oldest project) and Penguin Watch (which was the newest project at the start of the ethnography). The excerpts drawn on in this study are exemplar observations drawn out to illustrate important observations and therefore support arguments presented in the theoretical exploration and analysis of this case.

The combination of three different qualitative approaches provides valuable insights into the Zooniverse from different angles. This method is experimental, seeking to uncover the user perspective on a platform that entails a 'black box' type experience for outsiders. Therefore the study sought to examine the hidden practices and experiences of crowdsourcing citizen science. It focuses on the experiences that were most reflective of these.

4. Background to the Zooniverse

This study focuses on the Zooniverse, as it is currently the world's leading crowdsourcing citizen science website. It involves a large number of participants and a range of projects from different disciplines such as Astronomy, Zoology, and History (Banks, 2013). Luczak-Rosch et al. (2014) explain that Zooniverse users may contribute to multiple projects, and the crossover between these projects can be significant.

The Zooniverse platform was initially established by a small group of academics for a single astronomy project, but has now grown into a multi-project platform that has engaged over 1.3 million users so far. The Zooniverse projects are united by two distinct aims and objectives, the first of which being to solve specific scientific problems by serving as a reduction tool for data (and therefore professional, paid labour) intensive science and transforming raw user inputs into a 'data product' for use in academic research (Fortson et al., 2012). The second is a broader intention to engage in education and outreach activities, whether directly or through the ZooTeach resources. Perhaps the most famous project is Galaxy Zoo, but the platform now involves projects across disciplines as diverse as archaeology and seafloor biology. The rapid growth of the platform has brought with it complications: increasing numbers of scientists and institutions, a larger team of software developers, multiple funding grants, and a larger and more diverse user base. The basic process remains the same across the projects: the platform provides relatively simple categorisation tasks that are completed by a large crowd of users. The analysis provided by users is then used by professional scientists for further research.

The Zooniverse began as a post-doctoral research project at Oxford University, and it retains certain characteristics from these origins. A small group of astronomers were searching for a better solution to classifying galaxies, a relatively simple task that needed to be repeated a very large number of times. After developing a system to do it themselves – and realising how long this would take with only their input – they decided to develop a way to outsource this work to a crowd. As a leading person from the Zooniverse explained, that 'the original organisation model was a loose collaboration. That still exists.' There is now the added pressure to keep the Zooniverse running and viable as a platform, with many of those interviewed directly responsible for, and indeed dependent upon, the success of projects.

The role of the volunteer users on the platform has been crucial to the scientific output. It has been estimated that:

> the perfect graduate student — essentially, a human computer that never eats, sleeps or takes a bathroom break — spending 24 hours a day, seven days a week analyzing Galaxy Zoo's data would have needed three to five years to match what Galaxy Zoo's volunteers collectively accomplished in the project's first six months (Pinkowski, 2010).

While this notion of a 'perfect graduate student' is somewhat frightening, it could be possible to envisage a single graduate student working eight hours a day taking at least fifteen years (or more if they took lunch breaks, weekends, and holidays off!) to complete what the Galaxy Zoo volunteers took only half a year to do. However, this analogy of the 'human computer' is also useful in another way. Many of the categorisation tasks cannot currently be analysed by computer algorithms, yet with the recent innovations in machine learning, this may not be an obstacle for that much longer. In fact, the ongoing contributions

of human users provides a testing ground for new methods to automate the classification of images. Nevertheless, the Zooniverse has made the transition from a small group of researchers to becoming one of the most important citizen science crowdsourcing platforms.

The move from an ad-hoc project based out of a department at Oxford University to one of the leading citizen science platforms was far from straightforward. For example, one of the back-end software developers pointed out that "originally, the first GalaxyZoo Project was really not designed, it was just, let's just try this thing and it worked surprisingly well." From this starting point, increasing layers of complexity became added as the single project grew into a platform: more scientists and research institutions became involved, software developers were hired, funding was awarded from different organisations, and the team became split between Oxford and Chicago. This effects of this will be addressed in three parts: the effects of the research culture and the origins of the university, then the culture of software developers and the influence of open source ethics, and followed by a discussion of the impact of funding on an organisation that is neither based in the public or private sector.

The organisational culture of the Zooniverse is primarily shaped by the institutional experiences and pressures of the university sector. For many of the staff – especially those who founded the Zooniverse – the majority of their experience of work and organisation comes from this context. It is difficult to speak of a general culture in a university, partly because they are a site of ongoing transformation, but also because the university sector itself is heterogeneous. It should therefore be noted that Oxford University is particular in a number of ways. Firstly, it epitomises an elitist, research intensive institution. This means that there are comparatively high levels of funding and autonomy, along with a ubiquitous brand identity. This provides the freedom to innovate in various ways, backed up by the legitimacy of the institution. In this context, establishment of the first Zooniverse project and move to a platform was facilitated by the institution. In many universities this kind of experimentation but might be difficult to justify, but at Oxford University, as a leading person in the Zooniverse explained, "in astronomy at least, if you're a post-doc in particular, you have quite a lot of freedom to work on whatever." So this group of post-doctoral students – with the help of some volunteer web developers – started work on the platform. They continued to argue, "one of the key reasons GalaxyZoo happened was because we didn't have to ask for permission or it didn't cost anything. Well it cost ten quid because it was the domain name." Therefore the organisation "started without any structure, really, and it started – I guess in terms of organisations, it started as a very – we adopted a model that's common in astronomy. So it was a small group of researchers, trying to solve a single problem."

The culture of astronomers has more in common with computer programmers than social scientists. Therefore while these two are separate sets of cultural influences, there are areas of overlap. For example, a website developer on the Zooniverse explained that "we've all got roughly the same background . . . if I was looking for people to write code I would not look at astrophysicists because astronomers in general, although they do write their own code, they tend to write terrible code (Laughs)." So despite these differences, they nevertheless both have common references points in quantitative data and coding. The use of specific programmes to manage the labour process shapes the flow of work and the way that people

interact. For example, one of the front-end software developers explained that people collaborate between Chicago and Oxford: "working on the same code base but we interact with this website called GitHub where you can propose code changes and review them, edit them, and talk to each other and stuff like that. So the bulk of the interaction happens online through GitHub or [other] websites." These digitally enabled labour processes are accompanied by work practices and associated cultural features. One notable dimension is the proliferation of an Open Source Software (OSS) ethos. As the technical projects manager discussed, "I always saw the Zooniverse as a kind of brand of coding rebels . . . I just believe strongly in not letting money dictate what you do." Similarly, another web developer described the importance of Citizen Science:

> I think it's important because it makes science accessible again. I think for a lot of people science has become too complicated and academic and they're kind of almost snobby, "Oh you're not smart enough, you can't help us" and this just turns that on its head. You absolutely can help us and it doesn't matter what level you are, you could also learn more about science.

This democratic and collaborative element is shared between Citizen Science and the OSS movement. However, like with OSS, there is a question of whether the reality matches up to the intentions of those involved, particularly when external organisations become involved.

The management of the Zooniverse can be initially be understood as resulting from a combination of scientists and computer programmers that shaped the environment from which the Zooniverse emerged. It is therefore influenced by the institutional and cultural backgrounds of these respective groups but also by the associated pressures. In particular, the pressures of funding have a significant impact on the Zooniverse, not only in how it is organised but also limiting what it is able to do. The Zooniverse developed with a range of funding grants from different sources. These initially began as academic grants associated with the scientific projects, but they have grown in scope over time. For example, there have been a number of grants relating to public engagement or platform development. As a leading member of the Zooniverse explained, "despite my ranting about grants and how that constrains what we do, what you're really trying to do is spend the first – if we get a grant in, you want at least the second half of that to be beyond what you've written in the grant because you need to get the next grant." So the constraints of grant funding mean that even after securing one source of funding, the process of securing the next one begins quite quickly. "The goal", they continued, "can't be to get to the last day of the grant, to have spent all the money on exactly what you said and delivered only what you said because then you've got nowhere to go." Therefore the pressure of funding is constant and the work of securing funding has to be built into the activities of the Zooniverse.

5. The classifying process

The tensions between paid and unpaid labour stem from the contradictions involved in citizen science. There is a question of who 'owns' the data and outputs, 'how' can the data

be classified, 'what' is the classification experience like, and 'where' can further questions and alternative voices (including dissent) be heard. These concerns shape the process of scientific discovery, particularly as the analysis is pulled from a collaborative space. The Zooniverse itself did not begin as a platform for citizen science, rather it started as a novel way to address a particular problem. While it has grown to into a popular platform for citizen science, at its core the primary activity remains a transaction. The professional scientists bring their large datasets for categorisation, hoping for an end product that can be used to further their own research agenda. With this comes the pressures for academic performance, mainly in the form of publication outputs within limited time frames and submitted in refereed journals. Meaningful collaboration with the crowd can therefore become secondary in a process orientated towards specific outputs. The potential for new ideas or serendipitous discoveries to be found within the dataset by the crowd transcends the original research intentions. In practice, this results in different levels of engagement between scientists and users, while some projects regularly communicate and involve users, others remain strictly transactional.

User engagement takes two main forms on the Zooniverse. The first is the categorisation activity which is completed directly from a project specific web browser page. There are differences between projects, but they share a relatively common format. A picture (or in some cases a video or sound clip) is shown with different options for the user to select. In some projects this is a very quick process, for example, Sunspotter which takes only a few seconds as users are asked to select the more complex picture out of two. There are also projects that take significantly longer, for example the transcription tasks that users undertake with AnnoTate or Ancient Lives. The second engagement is on the Talk forum, which provides users with opportunity to communicate with each other about the images on individual projects.

The crowd of users are by nature a heterogeneous formation. This means that users come from a range of backgrounds, experiences, expertise, and motivation. This diverse range of backgrounds is also one of the potential strengths of citizen science. As has been demonstrated in research on innovation, often breakthroughs can be made when problems are approached laterally from a different discipline. This process is called 'pyramiding' and has been identified as an important way that innovation can be achieved with the 'broadcast search' type of crowdsourcing (Poetz and Prügl, 2010). Citizen science therefore has the potential to draw on a wide range of insights across disciplines. Yet the constitution of the Zooniverse is not as a broadcast or competition type crowdsourcing, instead requiring a kind of general labour, albeit one that can increase in pace with familiarity of the science and platform. The dimension of serendipitous discovery is not deliberately organised, instead remaining as an emergent possibility. The user community coalesces on Talk, with threads of discussions for users to communicate with each other. However, these are mainly limited to single projects, rather than encouraging a wider community and potential cross-fertilisation.

The two parts, the individual micro-work of classifications and the limited forum for discussion, do not form an ideal framework for citizen science. Most notably the issue of control remains complex. While users are encouraged to classify and talk about those classifications, this in itself does not represent a democratising of science. It is certainly true

that most people would not have had access to images of distant galaxies or rare animals before, but random access to images from a database is not the same as being handed elements of democratic control or even having users voices heard in the scientific process.

6. The user perspective

A wide range of explanations have been given for why users may or may not want to participate in online citizen science projects. For example, Raddick et al. (2010) explain that one of the main motivations for participating in a specific citizen science platform is the opportunity to learn about science through a hands-on experience. Others such as Mathieson (1991) highlight the issues of accessibility in regards to user participation, taking into account knowledge, access to the technological platforms such as computers and the Internet. According to Bonney et al. (2009), there can be a lack of specialist knowledge, misclassifications, and even resulting errors within the data produced using a citizen science platform. However, Lintott et al. (2011) and Willett et al. (2013) have illustrated that the utmost care is taken to ensure the legitimacy of classification as it can be applied to the wider scientific community. Other forms of project specific and or scientific assessment of citizen science platforms exist. For example, Raddick et al. (2009) also partly defines successful citizen science projects as the calibration of user contributions, for example, the extent to which appropriately sophisticated algorithms are employed to convert the raw data that is provided by participants into meaningful scientific insight (Wiggins and Crowston, 2011). Also other measures of effective project design and resource allocation include the provision of adequate training (Reisher and Potter, 2013), the division of effort between volunteers (Franzoni and Sauermaann, 2014) and the extent to which accurate data can be collected at a lower cost (Dai and Weld, 2010). Finally, Cox et al. (2015) have studied how the best performing projects tend to be those which are more established as well as those in the area of astronomy.

The citizen science aspect complicates the user experience on the Zooniverse. The users are engaging in a scientific project and therefore classifying scientific data, but this does not require the ability to relate their input to what is happening to the overall scientific data analysis. The process of categorising relatively abstract images can easily become disconnected from the overall research project and any potential findings. This was borne out in the user interviews. Only a third of the interviewees were aware of any research outputs from the projects they had participated in, while only three said they had any kind of relationship with the Zooniverse team (with an additional one explaining they had a relationship with the scientists on one project). Only three of the interviewees participated in the Talk forum, and this correlated with those who said they had some sort of relationship with the Zooniverse team. It is perhaps unsurprising that the users who participated in the forum were able to build these relationships, however it is surprising how many people had not used Talk. In general, users explained this lack of interaction in two ways. The first were those users simply not interested in this aspect, seeing their participation as classifying and having no need to talk to others about it. The second were users that had technical difficulties with the browser-based platform, with the user either unable to connect reliably or their previous negative experiences stopping them from trying again.

The users that were interviewed expressed complex motivations for involvement in the Zooniverse. These ranged from satisfaction, research, for fun, to contribute to science, for their own interest, or for teaching purposes. The interviewees can be broadly divided into two groups. The first had some sort of scientific education and were currently employed, retired from, or wanted to have worked in science. This meant the Zooniverse provided a valued opportunity to engage in science. An important subset of this were retired scientists. A number of these interviewees explained that they also engaged in other kinds of citizen science projects, particularly those involving the crowdsourcing of data capture. In a number of cases health reasons limited potential participation, something that the online platform allowed users to overcome. Another important subset of these were science teachers. For them the Zooniverse provided the opportunity to use a live scientific project in the classroom. This involved getting pupils to complete classifications in class and even setting participation as homework. The platform was therefore seen as an exciting way to teach about the importance of science in general and the scientific method specifically. With this group of users the notion of citizen science was very important. This was expressed in a broad understanding of scientific progress as being tied up with social progress more generally, in a kind of enlightenment logic. Within this there was a discussion of the importance of democratisation, however it did not extend to what this could mean in practice in the Zooniverse.

The second group of Zooniverse users identified from the interviewees were those who used the platform for fun. These users explained that they were motivated primarily by enjoyment. The low barriers to entry meant that classifications could be done at short notice or even while doing other activities like watching television. These motivations were regularly discussed by users on the Snapshot Serengeti project. There was little understanding of what the classifications would be used for, instead users enthusiastically discussed their enjoyment of seeing and collecting pictures of different animals. What united the two different groups of users was a common agreement that aspects of gamification should be adopted by the Zooniverse. Only two of the interviewees were against gamification, with three wanting some aspects, and the remainder in favour. For some of the interviewees gamification would be another way to involve users, expose more people to "science", and complete the categorisation tasks more quickly. However, the more reticent interviewees expressed concerns about undermining the seriousness of science and the output. Overwhelmingly, the interviewees spoke positively about the potential benefits of measuring user's contributions and rewarding or motivating this in various ways. This stands in contrast to the Zooniverse, which has decided not to implement such techniques.

Our study revealed a complex and constantly shifting relationship to the long term involvement in scientific data classification via a crowdsourced citizen science platform. The ethnography explores what it is like to categorise data and reveals that the user starts with enthusiasm and enjoyment in the beginning of the categorising process. For example:

> My first impression of this project is that it is excellent. I think that it is well thought out and potentially addictive. I love the topic, and although I'm not completely sure why we're

counting penguins I like it. I'm actually genuinely pleased to be coming back and having a go tomorrow.

However, as the ethnography continued, she found it difficult to get a sense of their value to classification process. While participating in the Penguin Watch project, there were two metrics available on the homepage: "640354 Images classified" and "7571 Volunteers participating". On returning the next day, she:

compared these numbers to the stats yesterday and I can see that over ten thousand images have been classified since yesterday. This is staggering and makes my contributions seem pitifully tiny. On one hand this makes me want to get started but on the other it also makes me think why bother, does my small/meagre contribution really make much of a difference?

The classification process involves examining a photograph and tagging all of the penguins present in the picture. In one instance she counted "62 penguins" and felt "proud . . . to spot so many tiny well-concealed penguins." However, she continued to ask rhetorically: "I wonder if I have found them all." Later, the ethnographer starts to notice different terrain in the pictures of penguins, suggesting perhaps quite different locations. Yet, "there is no information about where these photos were taken or any background as to when/where or why, at least not immediately." Thus, a basic question about the details of the scientific project behind the photographs is difficult to answer. Instead, she explains, "I suspect I will have to look around to find these answers myself and this information is not provided as it interferes with the classification process."

Over time the excitement and enthusiasm wanes and the user battles with more negative experiences associated with the categorising of the data. It is at this time when a positive intervention from the platform could be particularly effective. In lieu of this, the user must draw on their own personal motivations to keep going. For example, the ethnographer describes a series of challenging times over her year on the platform:

I classify for a while but there is nothing really compelling me today. Perhaps I am indifferent to their cute charms today for some reason, or maybe because I haven't seen any especially good pictures today. But I admit I am struggling to hold my interest and my attention wanes to other websites and parts of the internet. I persevere for a little while longer but only because I want to write more in the diary and not necessarily because I want to continue classifying . . . The first image I come to is obviously a faulty camera. This is seriously off-putting, which does not bode well when I reflect on how my contributions really don't make much difference . . . I'm presented with pretty much the same image as before and I must admit that my attention is well and truly waning now. I attempt to mark the minimum of 30 but it's difficult because they are so small and close together.

It is clear that at these moments that interventions could be made to motivate the user to continue with classifications. A particularly successful approach in many other peer-production platforms (those that are voluntary or not-for-profit) is for motivations to be drawn from community support and fellow participants. These kinds of platforms do not use monetary incentives, like the paid tasks on Amazon Mechanical Turk, requiring instead other reasons to be involved. The infrastructural limitations of the Zooniverse hamper the creation of a genuine and sustainable user community. While users can discuss images on Talk, these are limited to particular projects and focused around research specific topics. Again, from the user perspective these interactions can be fraught with contradictions. Talk can be a positive experience where the highs of the classifying activities can be shared. Conversely it can also be a negative place, with moderators ignoring or rebuffing the user for moving away from the set categorising task. Similarly, greater involvement in the scientific projects could improve motivation over all. Instead of feeling like a small cog in a broader research machine, democratic engagement could give users a stake in the completion of the project.

7. Conclusion

The Zooniverse has undergone a remarkable transition from a group of post-doctoral students to becoming one of the most successful online citizen science platforms. Collectively the users have contributed to forty different projects, providing a significant labour input that would have been difficult to achieve by alternative means. However, the relationships involved beyond the front page of the website are difficult to examine, appearing like a 'black box' (Scholz, 2015). This paper has been able to reveal a range of processes taking place on the platform, focusing on the tensions and contradictions that citizen science entails in practice.

The key difference between the Zooniverse and micro-work platforms like Amazon Mechanical Turk is the difference in potential contribution and motivation. The core labour process is similar, with larger projects broken down into small parts that can be easily completed by a single user. There is no need for collective interaction to participate, yet unlike Amazon Mechanical Turk, there are opportunities to do this. The hybridity in the crowdsourcing output of the Zooniverse has the potential to combine the strengths of micro-work with the broadcast search approach. Despite a number of examples of serendipitous discovery on the platform, this form of participation remains an emergent possibility. It is not deliberately organised, and like the possibilities of genuine co-creation or peer-production, is at the discretion of individual project teams on the platform.

The motivation of users has been shown to be a combination of scientific engagement and hedonistic enjoyment. While the motivation of users does not change the basic interaction on the platform (whatever the reason for participating the data is still being categorised), the former raises a number of important questions about the nature of citizen science. The Zooniverse did not begin as a citizen science project, rather it began as a search for a solution to a large data problem. Although it has grown to include an education and outreach dimension, this transactional relationship remains at the core of the platform. Returning to Lewenstein's (2004: 1) distinction between the basic involvement of non-professionals or the

more substantive democratic inclusion, it is clear that this tension is unresolved on the platform.

The Zooniverse operates in a competitive and output driven scientific context. This means that projects need to have secured some kind of funding and be able to demonstrate quantitative outputs. The heterogenous and diverse crowd could potentially contribute to the science projects in a variety of ways, but this entails a risk for the professional scientists involved. Citizen science entails a radical demand that is not currently being fulfilled. The notion that those outside of academia could contribute to and decide on the direction of science (which it should be remembered is in general publicly funded) requires those within academia to relinquish at least some element of control. This has the potential to blur the boundaries between professional and amateur or even work and play. If considered in the context of the Open Source Software movement discussed by many of the paid developer on the Zooniverse, there is the potential to envisage a process of scientific peer-production that is quite different to the caricature of the ivory tower. However, this requires a leap of political faith, one that is difficult to make within the confines of concurrent funding bids. Therefore, while the Zooniverse represents an important step forward in how data rich scientific research can be conducted, the question of how to fulfil the goals of citizen science as more than a motivational device remain open.

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