SCALING UP AND ROLLING OUT THROUGH THE WEB:

The "platformization" of citizen science and scientific citizenship

by Niclas Hagen

The purpose of this paper is to investigate online public participation and engagement in science through crowdsourcing platforms. In order to fulfil this purpose, this paper will use the crowdsourcing platform Zooniverse as a case study, as it constitutes the most prominent and established citizen science platform today. The point of departure for the analysis is that Zooniverse can be seen as a "platformization" of citizen science and scientific citizenship. The paper suggests that the mobilisation of individuals who participate and engage in science on the Zooniverse platform takes place through an epistemic culture that emphasises both authenticity and prospects of novel discoveries. Yet, in the process of turning "raw" data into useable data, Zooniverse has implemented a framework that structures the crowd, something that limits the sort of participation that is offered on the platform. This limitation means that the platform as a whole hardly be seen as fostering a more radical democratic inclusion, for example in the form of a co-production of scientific knowledge, that dissolves the institutional borders between scientists and non-professional volunteers.

Introduction

The developed world is increasingly becoming the world of direct public participation through social media, even to such degree that some observers are characterising the present economic system in terms of "platform capitalism". This terminology indicates a broader transformation, from a more conventional setting where individual firms compete for customers to a seemingly flatter and more participatory setting in which customers engage directly with each other, mediated through various web-based applications (Morozov, 2015). In an article in *The Guardian,* journalist Evgeny Morozov (2015) noted that with a smartphone "in their pockets, individuals can suddenly do things that previously required an array of institutions" (Morozov, 2015). In the early days of the Web, engagement between various actors took place through bulletin boards, Usenet discussions, home pages, chat rooms and blogs, but these venues have to a large degree been superseded by large-scale social media such as Facebook, Twitter, YouTube, Instagram, Flickr and Tumblr (Clarke et al., 2014, p. 1447). Concurrent with this development, experts on software studies have stressed the growing importance of software as an assembly that structures our social and everyday lives (Berry, 2015; van Dijck, 2013, p. 29).

This development can now also be observed within science, in the form of new and powerful ways to enrol and engage volunteers to participate in various citizen science projects through crowdsourcing platforms. Findings by Kullenberg and Kasperowski (2016) show that citizen science projects that are organised through digital platforms mark both qualitative and quantitative organisational change which citizens can be involved in new instances of the scientific process, and in much larger numbers due to the logistical affordances of digital platforms p. 13. The most prominent example of this development is Zooniverse (https://www.zooniverse.org), which currently hosts over one hundred (102) citizen science projects on its website (https://www.zooniverse.org/projects). These are projects that not only enrol but also rely on volunteers to take a direct part in scientific work, performing mainly classificatory tasks in different varieties. The classifications made by the volunteers are then aggregated, through algorithms, into scientific data used by researchers in their different projects. Moreover, Zooniverse not only distributes scientific tasks to volunteers but it also distributes the capacity to set up and launch projects to anyone who would like to enrol volunteers as part of their project design. The website offers an online citizen science project-building tool through which any individual or group of individuals can design, build and then, after a review and test process by the Zooniverse team and volunteers, launch projects that are part of the Zooniverse group of projects (https://www.zooniverse.org/lab/).

As a crowdsourcing platform that distributes scientific tasks to volunteers, as well as distributes the capacity to set up and launch projects, Zooniverse shares similarities with other crowdsourcing platforms, such as Amazon Mechanical Turk (MTurk). However, there are some significant differences between Zooniverse and MTurk that separates these two platforms. Firstly, whereas the MTurk is based on a commercial model (the participants are finacialy rewarded for completing assignments), Zooniverse relies on a non-commercial model, where participants take part in scientific work on a voluntary basis. Moreover, as pointed out by Graham and Greenhill (2016), differences between the MTurk and Zooniverse can also be seen in relation to the sort of engagement offered to the participants on each platform. In contrast to the MTurk platform, Zooniverse offers an engagement that moves beyond the immediate task at hand. Participants in the Zooniverse projects can, for example, be part of an epistemic culture or even in some cases to exercise resistance in relation to the classificatory assignments or tasks at hand in different projects (Kasperowski & Hillman, 2018; Graham & Greenhill, 2016). Moreover, as stated by Woodcock et al. (2017), in addition to the micro-work tasks offered on the MTurk, the work performed on the Zooniverse platform also harbours the chance of making serendipitous discoveries that, at least in theory but maybe not in practice, brings forward the possibility to contribute with something beyond the task at hand. On the basis of these differences, this paper will concentrate its analysis on the Zooniverse as this crowdsourcing platform provides a more comprehensive framework with regards to the "platformization" of public understanding and engagement in science than the MTurk platform.

Within STS, public participation and engagement in science have often been investigated and debated through the concept of citizen science and scientific citizenship, where public participation and engagement have been viewed in terms of deliberative measures and initiatives in relation to democratisation of science and science policy (see for example Irwin, 1995). Still, in order to fully understand the various implications of how crowdsourcing platforms such as Zooniverse mobilise public participation and engagement in science, further research is needed. Consequently, the purpose of this paper is to investigate online public participation and engagement in science through crowdsourcing platforms. Moreover, the paper intends to answer the following research questions: How are public participation and engagement in science mobilised on Zooniverse? How is scientific data and scientific knowledge produced on Zooniverse? And how can we relate the mobilisation and production of scientific knowledge to established understandings of citizen science and scientific citizenship within STS?

The disposition of the paper is as follows: The next section will discuss the analytical framework used in this paper. Thereafter, follows a discussion on previous research performed on citizen

science, as well as on digital platforms. The section that presents previous research will be followed by a section that will discuss how Zooniverse implements Citizen Science through a crowdsourcing framework. Finally, the paper concludes with a discussion that relates the findings in the previous section to notions within STS on citizen science and scientific citizenship.

Analytical framework: Digital platforms and "platformization"

The transformation of Web 1.0 to Web 2.0 yields a dichotomous difference between the conceptions of Web 1.0 as 'Web-information-source' and Web 2.0 as 'Web-as-participation-source' (McKelvey, 2011, p. 234; Song, 2010, p. 151; van Dijck & Nieborg, 2009). Within the academic context, the notion of platform has gained increased importance as *an analytical concept* as it captures various features that lie at the heart of the transformation of Web 1.0 to Web 2.0, as well as the ubiquitous societal presence of social media in the developed world. Platforms are usually hardware, software or services (or combinations thereof) that help structure or code social activities into formatted protocols and present these processes through user-friendly interfaces (van Dijck, 2012, p. 142). Platforms, as noted by van Dijck, are 'providers of software, (sometimes) hardware and services that help code social activities into a computational architecture' (van Dijck, 2013, p. 29). Digital platforms have an intrinsic ability to trigger and steer users' creative or communicative contributions, while users, through their interaction with the digital architecture of platforms, may in turn influence the flow of communication and information activated by a platform. José van Dijck and Thomas Poell (2013) links this dual ability as part of digital platforms' intrinsic ability to connect and mediate users' activities and to define how connections are taking shape, even though users themselves, can exert considerable influence over the contribution of content (p. 8). Scholars, who work in the area of media studies, analytically discuss this dual ability through the term "platformization" (Helmond, 2015), which Bratton (2015) describes as 'platforms provide an armature and induce processes to conform to it' (p. 42). Web-based platforms then contain a simultaneous movement that on the one hand distributes or de-centralises forms of autonomy to its users while, on the other hand, also standardises or re-centralises the conditions of communication and interaction among its users, thereby drawing many actors into a common architecture (Bratton, 2015; Helmond, 2015; Galloway, 2004). In conjunction to the current rapid growth of various digital platforms, resulting in an ecosystem (see below) of digital platforms, other scholars refers to "platformization" as the transformation of entire societal sectors, a transformation that infers the ability to reshape and reorganise society through the exercise of power (van Dijck, Poell & de Waal, 2018; Gillespie 2010 & 2015).

Closely linked to this de-centralising feature of platforms is the significance of protocols in order to coordinate and structure communications and actions. As noted by Galloway (2004), a protocol is a 'technique for achieving voluntary regulation within a contingent environment', which 'establishes the essential points necessary to enact an agreed-upon standard of action' (p. 7). An important aspect of the standardisation induced by platforms consists of various forms of protocols (van Dijck, 2013, p. 31). Another important feature concerns platforms' ability to perform large-scale quantifications. The novel and specific quantifying feature that is intrinsic to platforms such as Facebook and Twitter are their ability to produce automatically derived meta-data (such as time stamps and GPS-inferred locations) from smart phones (van Dijck & Poell, 2013, p. 9). When it comes to this ability to perform large-scale quantifications, each type of content that is handled on the platform can be treated in terms of data; with regard to social media platforms such as Facebook or Twitter, even relationships (friends, likes, trends) are quantified and represented as data (van Dijck & Poell, 2013, p. 9). In relation to the features that have been discussed above, the notion of popularity becomes crucial. Within the realm of social media and social media platforms, popularity revolves around pursuing online attention and getting users to regularly come back to the platform. As noted by, for example, Terranova (2012), the notion of attention has been mobilised as an economic category within the overall discourse on what has been called "the new economy" or the digital economy". Each platform has its distinct mechanisms in order to get and retain users' attention; nevertheless, van Dijck and Poell (2013) believe that these mechanisms simultaneously de-centralise (for example, by letting users generate users' platform content) and re-centralise (for example, by utilising algorithms that measure, rank and promote certain user generated content on the platform) control and influence over the content on a social media platform (pp. 6–7).

In addition to the features discussed above, the rapid growth of digital platforms during the latest decade has also resulted in an evolving ecosystem of various types of platforms, where van Dijck, Poell & de Waal (2018) makes a distinction between two main types of platforms (p. 12). The first type, the infrastructural platforms, are arguably the most influential type of platforms, many of them owned and operated by such influential high-tech companies as Alphabet-Google, Apple, Facebook, Amazon, and Microsoft. These infrastructural platforms form the core of the platform ecosystem, upon which other platforms and apps can be built or in other ways connected to as these infrastructural platforms also serves as gatekeepers through which data are managed, processed and stored. These types of platforms are for example search engines, browsers, servers and cloud computing, as well as social networking, app stores, geospatial and navigation services (van Dijck, Poell & de Waal, 2018 pp. 12–13). The second type

of platforms are sectorial platforms, which are directed and offer digital services towards particular sector or niche, such as news, transportation, education, health, hospitality. Often, these sectorial platforms are dependent and even built upon core features offered by the infrastructural platforms that gives these infrastructural platforms, and the companies that owns and runs these platforms, a considerable amount of power since they are in a unique position to connect, combine and even direct data streams, information, and intelligence within this evolving ecosystem of platforms (Plantin & Punathambekar, 2018; van Dijck, Poell & de Waal, 2018, pp.

16–17). Nevertheless, scholars investigating digital platforms and their effects, points upon the dynamic nature of the relationships between infrastructural and sectorial platforms, where sectorial platforms such as Facebook through time can evolve into a dominating infrastructural platform (Plantin & Punathambekar, 2018, pp. 169–170). Moreover, this flexible and dynamic character of the platform ecosystem, leads van Dijck, Poell & de Waal (2018) to argue for an analytical focus on 'how platforms work in specific contexts' rather than solely focusing on fixating specific platforms as either infrastructural or sectorial platforms (p. 19).

Previous research

This section will begin with an overview of previous research on citizen science, followed by an overview of previous research that has used the platform concept as its main analytical concept. This overview will encompass research performed in Internet and media studies.

Citizen science and scientific citizenship

The concept of citizen science has recently gained unprecedented visibility in academic literature (Kullenberg & Kasperowski, 2016; Follett & Strezov, 2015) and has also frequently been the subject of various science policy initiatives (see for example Nascimento et al., 2014; Pocock et al., 2014). Nevertheless, as noted by Kasperowski and Bronéus (2016), the concept has an ambiguous meaning, where they identify two main notions, which were both conceived of in the mid-nineteen nineties, long before such developments as Web 2.0. and Zooniverse. The first refers to representative notion of citizen science that often has taken the form of deliberative initiatives, which have been implemented in the form of negotiations between various stakeholders affected by scientific knowledge, informing policy decisions (Kasperowski & Bronéus, 2016; Hagendijk & Irwin, 2006; Irwin, 1995 & 2001). The relation between citizen science and scientific citizenship can be seen in terms of deliberation, dialogue and negotiations, where the goal of citizen science is to bridge the gap between the public and science that will lead to a more active scientific citizenship among the public. This is characterised by dialogue and deliberative decision-making between the public and science, in relation to risk and environmental threat (Bonney et al., 2016; Irwin, 1995). Another important aspect in relation to the representative notion of citizen science and scientific citizenship concerns the relationship between experts and lay people. Here, influential discussions within STS point to the epistemic differences between lay people and experts. Viewpoints that proscribe that these epistemic differences between lay knowledge and expertise should be accounted for and included in policy processes have been influential, advocating for the inclusion of ordinary citizens in scientific policy processes (e.g., Irwin 1995 & 2001; Wynne, 1992 & 1996). The notions of citizen science and scientific citizenship contain aspects of power, where the deliberative features of

citizen science and scientific citizenship are seen as a way to resolve an unequal distribution of power between the public and science.

The second conceptualisation concerns initiatives of a more local nature that often revolve around health or environmental issues such as pollution or draining of natural resources. In this more local context, citizen science becomes a strategy for citizens who are affected by these environmental issues in various ways, to influence political decision-making or legal processes. Thus, the primary objective in this second conceptualisation of citizen science is not to achieve scientific output, even though these local initiatives still rely on scientific standards – and in many cases scientific laboratories or instruments, for creating valid data (Kasperowski & Bronéus, 2016). Rather, this form of citizen science can be seen, as noted by Kullenberg (2015), as a form of resistance on behalf of citizens that can be very successful as long as it is able to produce valid scientific facts through established methods (p. 50). The funding is often structured through NGOs or crowdfunding campaigns and occasionally through traditional scientific funding. The participating citizens take an active role in defining the problem at hand as well as in the collection and analysis of the data (Ottinger, 2010; Orta-Martínez & Finer, 2010).

Platforms in Internet and digital media studies

Within Internet and digital media studies, the notion of platform has been used more extensively than in STS, often in conjunction with the development from Web 1.0 to 2.0. Here, the concept has evolved into an emerging sub-discipline (platform studies) to media and Internet studies, which originated from investigations and discussions on various material, including social and cultural dimensions of computer games (see, for example, Bogost & Monfort, 2009; Monfort & Bogost, 2009). One important assignment for scholars working within platform studies has been to establish the platform notion as a viable analytical concept. The main analytical advantage of the concept resides in how it enables us to understand how various computer related phenomena constitutes integration of various levels, an integration that not only involves studying the social and cultural dimensions at

hand, but also how these dimensions, on a deep structural level, is constituted through computer code (Berry, 2015, pp. 20–21; McKelvey, 2011). All these levels are joined and aligned upon platforms, which exert its social, political and cultural effects through this alignment.

However, in conjunction with the development from Web 1.0 to 2.0, the platform concept has attained expanded use among scholars that often critically investigate various aspects of social media, especially such digital media intermediaries as YouTube, Twitter and Facebook. Research that make use of the platform concept as part of investigations of social media, include Gillespie (2010) who discusses how such digital intermediaries such as YouTube use the concept in contemporary society, suggesting that that the main discursive work achieved by using the concept consists of its ability to bring various discourses 'into alignment without them unsettling each other' (Gillespie, 2010, p. 353). Moreover, this ability to align various levels includes such effects as a political ability to shape the social dynamics and interactions that take place upon platforms crafted by the logic of its algorithms, computer codes, business models and the implementation of its community guidelines (Gillespie, 2015, p. 2; Langlois et al., 2009). Others that have studied how digital platforms such as Facebook and Twitter shape the social dynamics and interactions that take place upon these digital platforms include Thomas (2013), Hands (2013), Gerlitz and Helmond (2013), as well as van Dijck (2013). In addition to the above research that focuses upon large-scale social media platforms, Goriunova

(2012) utilises the platform notion as her main analytical concept in her investigation of art and cultural production on the Internet.

Furthermore, Plantin (2015) has studied the relation between online public participation, platforms and novel possibilities for the public to extract, monitor and aggregate environmental data. The focus of Plantin's (2015) investigation is the mapping practices that could be seen among concerned citizen after the Fukushima Daiichi disaster in Japan, which gave rise to participative practices that revolved around extracting, monitoring and mapping environmental data upon radiation. Many of these participative practices took place on the Google Map platform, utilising the possibility to create and run applications on Google MAP (through the Google Map API) in order to create radiation maps that showed the level and spread of radiation after the disaster in 2011 (pp. 904, 906). In addition to this study, Plantin and Punathambekar (2018) has also been discussed platforms as an evolving critical and increasingly dominating and powerful societal infrastructure. This line of inquiry is also made by van Dijck, Poell & de Waal (2018), who investigates and discuss the transformation of entire societal sectors due to digital platforms and their growing social, cultural and political influence.

However, none of the previous research have investigated how online public participation and engagement in science is realised through such platforms as Zooniverse. The paper intends to leave a contribution to both the field of STS and the field of Internet and media studies by addressing this gap.

Zooniverse: Citizen science through a crowdsourcing platform

This section will address the question of how public participation and engagement in science is mobilised on Zooniverse? The point of departure for answering this question is that Zooniverse constitutes a digital platform that mobilises the public into a crowdsourcing framework. The origins of this crowdsourcing framework are to be found in the Galaxy Zoo project, from which the major objectives of the Zooniverse platform were developed.

From Galaxy Zoo to Zooniverse
Zooniverse originates from one of the projects that is featured on the platform, the Galaxy Zoo project (http://www.galaxyzoo.org/?_ga=1.202457361.1403256780.1435054658) that was launched in 2007 as a solution to the data-deluge problem within astronomy. This data-deluge problem came about since the Sloan Digital Sky Survey produced such a large amount of data, astronomical morphological images of galaxies, which made an analysis of the entire data-set by professional astronomers an impossibility with regard to the time required to go through the entire data-set, especially as each astronomical image required multiple independently made classifications in order to reach confidence (Meyer & Schroeder, 2015, pp. 82–83; Marshall, Lintott, & Fletcher, 2015, pp. 256–257). The idea for enrolling volunteers for classification of galaxies

was inspired by another citizen science project, the Stardust@home project (in which volunteers were asked to scan through astronomical images in order to identify dust grains in the images that originate from outside our Solar System), which was conducted by the University of Berkeley (Marshall, Lintott, & Fletcher, 2015, pp. 256–257; Stardust@home). Before the Galaxy Zoo web site was launched, professional astronomers had classified parts of the Sloan Digital Sky Survey, and this professional categorisation provided a baseline against which the classifications made by volunteers could be measured (Meyer & Schroeder, 2015, pp. 82–83). To date, the rate of participation in the Galaxy Zoo project amounts to several hundred thousand people, and the Galaxy Zoo project was later joined by other citizen science projects that were developed and hosted on the Zooniverse platform, which hosts projects from such diverse fields such as ecology to papyrology (Marshall, Lintott, & Fletcher, 2015, p. 261). Currently, the platform host over 100 citizen science projects, ranging from projects within the natural sciences, humanities, and medicine (https://www.zooniverse.org/projects). Moreover, the platform involves nearly two million users worldwide, and the projects hosted on the platform have altogether resulted in 160 peer-reviewed publications (https://www.zooniverse.org/about/highlights).

The origins of Zooniverse lies then in the Galaxy Zoo project, and the crowdsourcing solution developed within this project as a way to handle data-sets too big for researchers to classify on their own. This is a set up that still characterises how the platformed operates today:

> With the help of Zooniverse volunteers, researchers can analyse their information more quickly and accurately than would otherwise be possible, saving time and resources, advancing the ability of computers to do the same tasks, and leading to faster progress and understanding of the world, getting to exciting results more quickly (https://www.zooniverse.org/about).

Consequently, the platform has two major objectives, the first of which is to provide an online tool through which (mainly) professional researchers can turn "raw" data into usable data by the help of a large crowd of users that performs relatively simple classifying tasks. The other objective is a broader ambition to engage in scientific education and outreach activities of various sorts through the projects and the platform's crowdsourcing framework (Woodcock et. al., 2017). The essential aspect of realising these two objectives are the twin movements of de-centralisation and re-centralisation, and these two movements will be investigated in more detail below in relation to building and managing a crowd of volunteers and turning "raw data" into usable data. These two features are fundamental in order to conduct citizen science through a crowdsourced framework.

Mobilising a crowd of volunteers

The first aspect of de-centralising parts of the research process involves the unique human abilities that forms the basis of the various forms of classifications performed by the volunteers on the Zooniverse platform. One of the main limitations of an automated process wherein the empirical material in need of classifications would be classified through an automated process (for example by an AI) resides in the (still) unique human capability to spot various forms of anomalies that cannot be discovered by, for example, an AI or an algorithm (Kasperowski & Hagen, 2019, p. 172):

> The major challenge of 21st century research is dealing with the flood of information we can now collect about the world around us. Computers can help, but in many fields the human ability for pattern recognition — and our ability to be surprised — makes us superior (https://www.zooniverse.org/about).

The essential point of departure that enables the de-centralisation parts of the research process to volunteers is then the unique abilities of human perception and pattern recognition, which gives humans the unique capability for both "mundane" classificatory work but also for spotting anomalies that might harbour the seeds for novel scientific discoveries. One example of the latter is the astronomical phenomena (that goes under the name Hanny's Voorwerp) discovered by the Dutch schoolteacher Hanny van Arkel, while she participated in the Zooniverse project Galaxy Zoo. Hanny van Arkel spotted an anomaly in the images meant for classification and the phenomena, which is still not fully explained, resulted in a scientific paper in which van Arkel was one of the co-authors (Kasperowski and Hagen, 2019, pp. 175–176; https://www.hannysvoorwerp.com/3-voorwerp-in-the-pictures/). These kinds of discoveries, made by a single individual with a resulting co-authorship on a scientific paper, are of course an exception, but it nevertheless constitutes a harbouring possibility rhetorically used by the platform to attract, mobilise and retain volunteers (see below).

So, the basis for de-centralising parts of the research process to non-scientists resides in perceptive abilities among humans, an ability that opens up for mobilising volunteers into handling large data-sets in the form of unclassified images through a crowdsourcing framework. Still, in order to take advantage of this unique ability, volunteers need to be attracted, mobilised but also to "encouraged" to actually do the classification tasks that are at the heart of Zooniverse's objectives. As a digital platform, Zooniverse is part of what Terranova (2012) has termed "The Attention Economy", in which attention can become not simply a commodity like others, but a kind of capital assess. In order then to de-centralise parts of the research process, Zooniverse needs to make itself relevant, as well as attract the attention of the crowd in the vast competition between websites on the Web. In order to attract the attention of volunteers, Zooniverse reaches out to the crowd by invoking both authenticity and the possibility for significant discoveries like the one made by Hanny van Arkel, but also that the contributions made by every volunteer increases our understanding of our world:

> You'll be able to study authentic objects of interest gathered by researchers, like images of faraway galaxies, historical records and diaries, or videos of animals in their natural habitats. By answering simple questions about them, you'll help contribute to our understanding of our world, our history, our Universe, and more [...] Zooniverse projects are constructed with the aim of converting volunteers' efforts into measurable results. These projects have produced a large number of published research papers, as well as several open-source sets of analyzed data. In some cases, Zooniverse volunteers have even made completely unexpected and scientifically significant discoveries (https://www.zooniverse.org/about).

The prospect of an active involvement in the scientific process, of actually doing "real" scientific work is also an aspect that are pointed upon in previous research on what motivates volunteers to participate in online citizen science. For example, Jennet et. al. (2016) found that volunteers initially are motivated by curiosity, interest in science, and a desire to contribute to research (p. 7).

To keep the attention of the crowd, the platform has a low threshold that enables anyone to immediately contribute the progress of

science, regardless of previous skills or formal education. Moreover, the individual volunteers who is attracted to the platform has also a wide range of projects to choose from, all developed and operated with the same incentives of inclusiveness and a low-threshold that welcomes anyone to take part in the production of scientific knowledge:

> You don't need any specialised background, training, or expertise to participate in any Zooniverse projects. We make it easy for anyone to contribute to real academic research, on their own computer, at their own convenience […] With our wide-ranging and ever-expanding suite of projects, covering many disciplines and topics across the sciences and humanities, there's a place for anyone and everyone to explore, learn and have fun in the Zooniverse. To volunteer with us, just go to the Projects page, choose one you like the look of, and get started (https://www.zooniverse.org/about).

Following Kasperowski and Hillman (2018) the incentives used by Zooniverse to gain and retain the attention of the crowd can be seen as a way to mobilise the crowd into an epistemic culture. This epistemic culture revolves around the values of authenticity, volunteering on Zooniverse means that you take part in solving authentic scientific problems, but also around inclusiveness where everyone can take part in the endeavour to expand scientific knowledge through the micro-tasks performed by the volunteers. Moreover, this epistemic culture also contains a value of equality, where the outsider can be on par with the scientists both in the form of a collective and as an individual depending on the nature of discovery. Here, Hanny van Arkel's discovery of "Hanny's Voorwerp" constitutes a possibility for the anyone in the large crowd of volunteers of individual discovery, to see something that no one has seen before (Kasperowski & Hillman, 2018, p. 584). Another strategy for mobilising individuals into the epistemic culture of Zooniverse consists of providing discussion boards, both in connection to each individual citizen science project on the platform, but also a discussion board connected to whole Zooniverse platform:

> A significant amount of this research takes place on the Zooniverse discussion boards, where volunteers can work together with each other and with the research teams. These boards are integrated with each project to allow for everything from quick hashtagging to in-depth collaborative analysis. There is also a central Zooniverse board for general chat and discussion about Zooniverse-wide matters. (https://www.zooniverse.org/about).

Yet, realising this incentive of an authentic participation in the scientific process is of course connected to, but also subordinated the objective of turning "raw" data into useable data. This is a process that is highly structured and also dependent on algorithms that organises the crowd of volunteers into a collective, thereby dissolving the individual classifier into a collective.

Turning "raw" data into useable data

As already mentioned in the previous section, one of the main objectives for Zooniverse are to provide an online tool through which (mainly) professional researchers can turn "raw" data into usable data. In contrast to the mobilisation of a large crowd of volunteers, which is based on a de-centralisation of parts of the research process, the process of turning "raw" data into useable data is based on the other side of the twin movements of "platformization; re-centralisation. To ensure data quality, the platform relies on protocols that guides the classificatory work performed in each project hosted on the platform (Kasperowski & Hagen, 2019, p. 177). Naturally, these protocols are developed and implemented in relation to the nature of the empirical material in need of classification in each project (pictures of galaxies, transcription of documents etc.), but nevertheless the epistemological basis for all projects consists of standardised protocols, that the crowd are expected to follow in order to ensure that "raw" data is turned into useable data for the researchers. Moreover, the usage of guiding protocols is combined with another form re-centralisation in which each individual classification made by the volunteers is combined into an aggregated classification (Hines, Kosmala, Swanson & Lintott, 2015, p. 3975). Since volunteers can make mistakes, each item (images, letters in a document that are to be transcribed etc.) is shown to and classified by multiple individuals, and a critical step for achieving good data quality is to combine these classifications into one aggregated classification, something that is done through so called aggregation algorithms:

> Our projects combine contributions from many individual volunteers, relying on a version of the 'wisdom of crowds' to produce reliable and accurate data. By having many people look at the data we often can also estimate how likely we are to make an error (https://www.zooniverse.org/about).

As argued by Gillespie (2014), algorithms are more than tools. They are also stabilisers of trust, practical and symbolic assurances that their evaluations and output are both fair and accurate, free from subjectivity, error or attempted influence (p. 179). This argument is very much valid in relation to the re-centralisation of classification through the aggregation algorithms used by Zooniverse. From a research point of view, the legitimacy of Zooniverse rests on its ability to produce high-quality data; that is, the classifications made on the platform has to be correct and accurate in order to generate trust among the researchers who use the platform for classifying large data-sets. Here, the combination of individual classifications through aggregation algorithms removes the subjectivity and individual errors made by the crowd of volunteers, transforming the work conducted by non-professional volunteers into a productive force that can, through these algorithms, be on par with the trained scientists (Kasperowski & Hillman, 2018, p. 584; Kasperowski & Hagen, 2019, p.177). In this sense, the production of useable data on Zooniverse is based upon what Gillespie (2014) denotes as algorithmic objectivity (p. 181).

Consequently, the process of re-centralisation takes place in two instances. First, protocols are used that guides the individual volunteers' classifications as a way to standardise their micro-tasks on the platform and, second, each individual micro-task are subsequently combined by aggregation algorithms into one aggregated classification. On the basis of research performed within the context of social media, Helmond (2015) points upon how "platformization" is also process of reconfiguration with regards to such issues as website infrastructure, an argument that van Dijck, Poell & de Waal (2018) extends to include the transformation of entire societal sectors, a transformation that infers the ability to reshape and reorganise parts or even whole societies. With regards to the issue at hand in this paper, citizen science and scientific citizenship, this section will discuss if and how the Zooniverse actually are making citizen science "platform ready", an approach that oblige the following discussion to begin with how the notion of citizen science have been conceptualized and understood in STS.

Zooniverse: Making Citizen Science "Platform Ready"?

Within STS, citizen science has come to revolve around various aspects of democratic representation, and participation, which within the context citizen science implies a:

> Meeting point between different forms of knowledge and understanding. It also implies the possibility of cross-fertilization within a diverse area of different knowledges. Especially for the institutions of science, it will involve change but also reflexivity in the face of social pressures. Citizen science thus implies the recognition of new social and knowledge relations (Irwin 1995, p. 166).

According to Woolley et al. (2016), this form of representative citizen science has the goal of emancipating science from its traditional institutional and professional setting. On the basis of this interpretation of what citizen science entails, community-based urban planning or environmental projects that are responsive to local needs, as well as the involvement of lay people and their lay knowledge in order to achieve a more democratic governance of science are seen as prime examples of citizen science (Woolley et al., 2016). This democratic governance of science is characterised by dialogue and deliberative decision-making between the public and science in relation to risk and environmental threat (Bonney et al., 2016; Irwin, 1995). As noted by Woolley et al. (2016), the word citizen implies, at its most immediate level, a relation between individuals and the societies that they live within (Woolley et al., 2016). The notion of scientific citizenship infers that the relation between individuals and science is to be seen and based upon dialogue and deliberative decision-making, where the relationship between science and democracy should not 'be about the search for universal solutions and institutional fixes, but rather the development of an open and critical discussion between researchers, policy makers, and citizens' (Irwin, 2001, p. 16). Arguments within STS regarding citizen science and scientific citizenship connects then to discussions and understandings within the field that advocates the need for an increased participation as a way to emancipate science and increase the epistemic representation of citizens. These discussions and understanding, in turn, follows a broader development that sees the need to expand participation into what Carpentier (2011) denotes as "alternative areas".

These are areas that lies outside the more traditional arenas of political decision making, a position that also implies an expansion of what areas or parts of the society that are to be seen as political (Carpentier, 2012, pp. 167–168). As shown above, the model that lies at the heart of this position within STS revolves around a participatory moment that is located within communication, as deliberative democracy refers to decision making by discussion among free and equal citizens (Soneryd & Sundqvist, 2019; Carpentier, 2012, p. 168). The limitations and even incompleteness of deliberative contexts have also sparked an interest as well as discussions within the STS-field, where the need for a proper co-production with regards to science and the use of scientific knowledge within the society is argued for (see for example Irwin, 2001; Elam & Bertilsson, 2003). Nevertheless, from the perspective of democratic theory, the dominating positions and understandings about public participation and engagement within science held by the STS-field can be seen as advocating a maximalist position with regards to participation in science. This maximisation implies a broadening of the set of actors in political activities but also, and maybe more important, also a broadening of the societal spheres that are to be considered as political and therefore also subject to political and democratic discussions as well as different forms of interventions (Carpentier, 2012, p. 169).

With regards to the issues discussed above, the question that lies at core concerns the nature of the participation offered on the Zooniverse platform. Here, a differentiation between access, interaction and participation will enable a more detailed discussion concerning if in fact Zooniverse is making citizen science and scientific citizenship "platform ready". The concept of access is based on presence; for example, presence in an organizational structure or within a community or, as in the case of Zooniverse, presence on the platform and within the research process. Interaction emphasises the social-communicative relationships shaped by actors on the basis of shared interests, purposes and values, or common knowledge (Carpentier, 2012, 174–175). Also, this aspect is provided on Zooniverse, in the form of the discussions forums that are an integral part of the platform's infrastructure, as well as of its epistemic culture. Still, the essential point to be made in relation to the notions of access and interaction is that even if they constitute important, if not essential conditions, for

the possibility of participation, they cannot be equated with participation. The difference between access, interaction (which both can be found on the Zooniverse platform) and participation is connected to power and equal power relations in decision-making (Carpentier, 2012, pp. 174-175). For an STS- audience, the notion of power and equal power relations is not new, and the key aspect revolves around what kind of power relations that is contained in the twin movements of de-centralisation and re-centralisation. On the basis of what has been showed and discussed in this and the previous section, it can be argued that Zooniverse do provide both access and interaction to the volunteers but when it comes to participation in a sense of a co-production of scientific knowledge, Zooniverse still has some way to go before this kind of participation is fulfilled on the platform.

In line with the discussion above on a deficiency of a more radical inclusion of the Zooniverse crowd, previous research shows how this deficiency gives rise to various forms of tensions (c.f Mansell, 2013). Here, Woodcock et. al. points upon experiences of "alienation" among individual volunteers as their classifications does not seem to make much of a difference compared to the total amount of classifications made in each citizen science projects on the platform. Over time, according to Woodcock et. al, the initial excitement and enthusiasm wanes and is replaced by with more negative experiences associated with the classifying the data (Woodcock et al., 2017). Tensions of another kind is discussed by Kasperowski's and Hillman's (2018) investigation of the discussion forum connected to the Galazy Zoo project, identifies how tensions develops in Galaxy Zoo in relation to the standardised protocols that guides and directs the classifying micro-tasks de-centralised to the crowd. Images that do not comply with the standardised protocol captures the interest of some part of Galaxy Zoo's crowd of volunteers, sparking an interest but also expectations that the anomaly might in fact be another "Hanny's Voorwerp", a discovery of an unknown astronomical phenomena (581–582). Often, though, these anomalies turn out to be optical artefacts, either resulting from the telescope that has produced the image in question, or the software involved in the Galaxy Zoo.

In many cases inquiries made by the volunteers about these anomalies end up as topics on the project's discussion forum where sometimes examination and discussion lead up not only to a detailed discussion and analysis of astronomical phenomena but also of imaging artefacts, which involves sharing knowledge and resources (for example different astronomical databases outside the Galaxy Zoo project) for obtaining deeper knowledge among the volunteers. These discussions and subsequent collaborations among the volunteers extend far beyond the main goal of the classifying images of galaxies, which give rise to responses among the forum's moderators, as well as researchers, that encourage the volunteers to focus on the task of image classification rather than pursuing other forms of activities (Kasperowski & Hillman, 2018, pp. 579–580). Arguing from user perspective, Woodcock et al. (2017), means that interactions on the discussions boards at times

can be contradictory, being a positive experience as the height of the classificatory activities can be shared and discussed, but also negative when moderators rebuff the volunteer for moving away from the core activity of classifying images (Woodcock et. al., 2017).

The reason for this can partly be attributed to fact that the origins of the platform was not seen in terms of realising neither citizen science nor scientific citizenship, but rather as a solution to the growing problem of handling and managing large data sets. Consequently, the twin movements of de and re-centralisation of the research process employed by Zooniverse came to be a suitable solution to handling and managing large data sets but, as Woodcock et al. (2017) points out, 'the need for reliable and large-scale data shapes the interactions that scientists have with the crowd, seeking to gather a finished data product that can be used in research' (Woodcock et al., 2017). Even though individual projects that are hosted on the platform might approach more radical forms of inclusion in their involvement of the crowd for performing micro-tasks of classifications, the platform as a whole can hardly be seen as fostering a more radical democratic inclusion, for example in the form of a co-production of scientific knowledge, that dissolves the institutional borders between scientists and non-professional volunteers (Soneryd & Sunqvist, 2019; Elam & Bertilsson, 2003). Another reason can be traced to the highly structured and controlled participation that are intrinsic to Zooniverse's design also yield an imbalance of power between researchers and volunteers. Following Gillespie's (2015) observation that 'platforms shape the social dynamics that depend on them', and that their 'technical design, economic imperatives, regulatory frameworks, and public character, have distinct consequences for what user are able to do, and in fact do' (p. 21), the tensions discussed above can also be seen as a reaction and a resistance to the way the design of the Zooniverse platform contains intrinsic relations of power and authority.

In their investigation, Kasperowski and Hillman (2018) understands the issues discussed above in terms of a central tension, or paradox, the epistemic culture on Zooniverse. Volunteers are mobilised into this epistemic culture as a distributed collective, and an overwhelming majority of the contributions made to the scientific process will be as a collective, where individual classifications are combined through aggregation algorithms into useable data for science. However, the prospect of individual discoveries, like the one made by the Dutch schoolteacher Hanny van Arkel, is also very much part of the epistemic culture within Zooniverse (p. 582). Experiences of "alienation" and instances when volunteers step outside the formulated and standardised micro-tasks that constitutes the main work performed on the platform is then experiences that can be seen and understood in cultural terms. Nevertheless, as shown in this section, these issues could also be seen and understood in terms of the dual "platformization" process of de-centralisation and re-centralisation. Against this background, the initial question posed in this section whether

Zooniverse can be said to make citizen science "platform ready" have to be answered negatively in as much as we understand citizen science in terms as encompassing a more radical inclusion of the public in the production and usage of scientific knowledge.

Concluding Remarks

The Zooniverse platform signifies a novel development within the field of citizen science and scientific citizenship. It offers, through a process of "platfromization", a direct and highly accessible way for the public to become part of the production of scientific knowledge. However, as shown in the last section of this paper, this direct and accessible way comes with a price in relation to what kind of engagement offered to the public. Whereas the platform does offer both access to (become part of scientific research) and interaction among (volunteers and researchers), it cannot be said to offer a more radical form of inclusion in the production of scientific knowledge. In this respect, the highly structured involvement of the volunteers yields a power imbalance between volunteers, researchers and the platform itself.

However, this aspect also depends on the definitions and understandings of citizen science and scientific citizenship. Since its formulation for almost twenty-five years ago, the field has undergone a rapid development, especially as a consequence of the development within digital technologies. Zooniverse is a prime example of this development. Apart from setting the light on what kind of inclusion and participation that is offered on Zooniverse, the platformization of citizen science and scientific citizenship also sets light on what we actually mean with these two concepts. Maybe we have to make a differentiation between various forms of citizen science and scientific citizenship that will enable us to pinpoint and discuss what various actors refer to when they make use of and designates their activities as citizen science or as fostering a scientific citizenship. To be fair, Zooniverse themselves designates their form of public engagement as a people-powered research, a designation that does not exclude an analysis performed in this paper, but which nevertheless sets light on the various terms that exists and are use. In order to avoid that the notion of both citizen science and scientific citizenship becomes watered down and losses its meaning, further research and discussions on processes of "platfromization" and consequences of the digital development is needed.

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