

Institution: University of Portsmouth		
Unit of Assessment: UoA 9: Physics		
Title of case study: Citizen Science with the Zooniverse		
Period when the underpinning research was undertaken: 2000 - 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI: Pure
Karen Masters Bob Nichol	Reader in Astronomy & Astrophysics Professor of Astrophysics, Pro Vice-Chancellor (2018-date)	01/10/2008 - 30/09/2019 01/08/2004 - date
Will Percival Daniel Thomas Thomas Collett	Professor of Cosmology Professor of Astrophysics Royal Society University Research Fellow	01/10/2005 - 31/07/2018 01/02/2007 - date 01/09/2014 - date
Period when the claimed impact occurred: 2013 onwards		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact		
<p>Zooniverse citizen science projects have reached over 2.22 million people (1.4 million new people since August 2013). This impact includes changes of understanding and behaviour of members of the public providing classifications for over 300 different projects, as well as project use in formal and informal education, changes to the behaviour of researchers engaged in new research using citizen science methods, and changes internationally, particularly to environmental policy and disaster relief. Portsmouth has made major contributions to the underpinning and ongoing research for Galaxy Zoo, which was the foundation for the Zooniverse and led directly to its wide impact.</p>		
 <p>The screenshot shows the Zooniverse website front page. At the top, it says 'THE ZOOVERSE WORKS' followed by a large number '570,056,004' in teal. Below this, it says 'CLASSIFICATIONS SO FAR BY 2,253,810 REGISTERED VOLUNTEERS'. There is a small paragraph of text describing the community and a 'SIGN IN OR REGISTER TO GET STARTED' section with 'Sign in' and 'Register' buttons. At the bottom, there is a grid of many small photos of diverse people, with the word 'Screenshot' at the bottom center.</p>		
<p><i>Figure 1 - The Zooniverse website (https://www.zooniverse.org/) front page, showing ongoing updates of its extraordinary reach</i></p>		
2. Underpinning research		
<p>The Zooniverse platform (www.zooniverse.org) and Portsmouth's links to it can be traced back to the Sloan Digital Sky Survey [SDSS (R1)] and the closely related Galaxy Zoo project (www.galaxyzoo.org) - both of which are astronomical collaborations in which Portsmouth researchers have played a leading role.</p> <p>Professor Bob Nichol has been a key member of SDSS since 1993, arriving at Portsmouth's Institute of Cosmology and Gravitation (ICG) in 2004. Recent ICG members continue to have leadership roles in ongoing generations of SDSS (Dr Karen Masters - SDSS-IV Spokesperson - at Portsmouth 2008-2019; Professor Will Percival - eBOSS Project Scientist - at Portsmouth 2005-2018). Throughout, SDSS has been central to the modern standard model of Cosmology.</p> <p>The development of digital detector technology enabled astronomical surveys (including SDSS as the first of these surveying a large fraction of the sky) to create so many images of galaxies that</p>		

by 2007 it had become impossible for astronomers to visually inspect all images. Even now, computer-based algorithms still struggle to do this task as accurately as humans.

To overcome the challenge of analysing so many galaxy images, Galaxy Zoo (GZ) was launched in 2007 (zoo1.galaxyzoo.org archives the original site) by a team that included Portsmouth researchers Nichol, Professor Daniel Thomas and technical help by then Portsmouth based postdoc Dr Edd Edmondson (now at UCL). Portsmouth expertise in SDSS and links to the SDSS image server were critical to the smooth running of the site. On July 11, 2007, the GZ project was launched to the public. Within twelve hours, GZ began receiving 20,000 classifications per hour (peaking at 70,000 per hour on the second day), driven by a global media interest in the project. After 10 days, the public had submitted 8 million classifications; by early 2008, when the first GZ research papers were published (Portsmouth lead author) (R2), 100,000 volunteers had inspected more than 900,000 galaxies, each 38 times on average.

Early research using GZ classifications, led by Portsmouth researchers Steven Bamford (UoP 2005-2008) (R2) and Masters (R3) demonstrated the utility of this crowdsourcing technique. These and other works demonstrated without doubt that online citizen science could be used to obtain data useful for scientific studies (in these examples understanding galaxy evolution), suggesting that the technique should be expanded to other areas. The early success of GZ (both as a public engagement project and as a tool for analysing data sets) directly supported the launch of the Zooniverse platform, designed to support similar projects on any topic. The development of Zooniverse was led by Oxford-based researchers with key involvement from Portsmouth: Galaxy Zoo was the first project to relaunch on Zooniverse, and Masters was named Galaxy Zoo Project Scientist shortly after launch in recognition of her leadership role. In 2019, the Galaxy Zoo science team won the RAS Group Award.

The Zooniverse is now a mature platform; its latest code base enables hundreds of projects to run on the site across many areas of research. Since 2014 Portsmouth has been an official member of the Zooniverse collaboration, and has employed Data Scientist Dr Coleman Krawczyk (2014-present). He works directly with the Zooniverse team to develop new data analysis and visualisation tools, and to help Zooniverse researchers across all projects to obtain effective output from the citizen science input. As well as important ongoing results led by Portsmouth researchers coming out of Galaxy Zoo classifications in the area of galaxy evolution (R4,R5), Portsmouth researcher Thomas Collett has been involved in finding gravitational lenses in the Space Warps project (R6), and ICG academic staff member Andrew Lundgren is involved in the project which feeds data to Gravity Spy. The data analysis enabled by Zooniverse projects has now touched vast areas of academia, from climate change to ancient language translation.

3. References to the research

(R1) York D. G. et al. (2000). The Sloan Digital Sky Survey: Technical Summary. *Astronomical Journal*, 120(3), 1579-1587. [DOI:10.1086/301513](https://doi.org/10.1086/301513) (**Bob Nichol** is an author on this paper and an SDSS "Builder")

(R2) Bamford, S.P. et al. (2009). Galaxy Zoo: the dependence of morphology and colour on environment. *Monthly Notices of the Royal Astronomical Society*, 393, 1324-1352. [DOI:10.1111/j.1365-2966.2008.14252.x](https://doi.org/10.1111/j.1365-2966.2008.14252.x) (16 authors, including Steven Bamford, **Bob Nichol**, **Daniel Thomas**, Edd Edmondson)

(R3) **Masters, K.L.** et al. (2010). Galaxy Zoo: passive red spirals. *Monthly Notices of the Royal Astronomical Society*, 405(2), 783-799. [DOI:10.1111/j.1365-2966.2010.16503.x](https://doi.org/10.1111/j.1365-2966.2010.16503.x) (17 authors, including **Karen Masters**, **Bob Nichol**, Edd Edmondson)

(R4) Lintott, C.J. et al. (2011). Galaxy Zoo 1: data release of morphological classifications for nearly 900 000 galaxies. *Monthly Notices of the Royal Astronomical Society*, 410, 166-178. [DOI:10.1111/j.1365-2966.2010.17432.x](https://doi.org/10.1111/j.1365-2966.2010.17432.x) (14 authors including Steven Bamford, **Karen Masters**, **Daniel Thomas**, Edd Edmondson, **Bob Nichol**)

(R5) **Masters, K.L.** et al. (2011). Galaxy Zoo: bars in disc galaxies. *Monthly Notices of the Royal Astronomical Society*, 411, 2026-2034. [DOI:10.1111/j.1365-2966.2010.17834.x](https://doi.org/10.1111/j.1365-2966.2010.17834.x) (11 authors including **Karen Masters**, **Bob Nichol**, Edd Edmondson, **Daniel Thomas**)

(R6) Marshall, P.J. et al. (2015). Space Warps- I: Crowdsourcing the Discovery of Gravitational Lenses. *Monthly Notices of the Royal Astronomical Society* 445 (2), 1171-1190.
[DOI:10.1093/mnras/stv2009](https://doi.org/10.1093/mnras/stv2009) (22 authors including **Thomas Collett**)

Evidence for the quality of research

The underpinning research outlined above was published in foremost international astronomical journals, including robust peer review. The impact factor of these journals is 5.4 to 5.5.

4. Details of the impact

Here we describe the impact from active Zooniverse projects which occurred during the period 2013-2020. In this period, there was a massive expansion in the number, variety and scope of Zooniverse projects. At the end of 2020, 69 active projects and 334 total projects reside on and operate from the site. Throughout the period since 2014, Portsmouth has hosted a Zooniverse Data Scientist (Krawczyk) who has contributed directly to the development and analysis of many Zooniverse projects (e.g. AnnoTate, Anti-Slavery Manuscripts, Etch-a-cell, Galaxy Builder, Galaxy Zoo, Galaxy Zoo:3D, Gravity Spy, Penguin Watch, Planet Hunters:TESS, Planetary Response Network, SCOTUS Notes, Seabirdwatch). Portsmouth has commissioned an independent review of the impact of Zooniverse projects, based on published works (S1), and this work is discussed below. The Zooniverse has changed participants' understanding of science, how science is taught both formally and informally, and even how science is done.

Impact on Zooniverse Public Users: actively engaging with research

Our citizen science projects have had significant social and cultural impacts through the engagement and general education of hundreds of thousands of community volunteers, as well as by inspiring volunteers to become invested in science. The success of our citizen science projects lies in the visible impact of the volunteers' work on current research, making citizens part of the scientific process, and changing their opinions about research and science in particular (S1-S4).

The reach of Galaxy Zoo (GZ) and the Zooniverse of citizen science projects extends to 2.22 million members of the public with registered accounts, 1.4 million of whom have signed up since August 2013. The Zooniverse has been highly successful in attracting both rigorous science projects and volunteers (S5-S6), and since 2016 these volunteers on average make 5.6 million classifications per month (across all projects) and also post around 58,000 comments to the projects' Talk boards each month (S7). This has enabled over 330 studies to be completed in areas from the Arts to Medicine, because of the public user participation (S7).

Studies evaluating the benefits to individuals involved in the Zooniverse (including by Masters at Portsmouth (S2)) have shown that volunteers measurably learn about science through engaging with the site, even if the projects they engage with do not include direct educational content (S2-S4). The volunteers' project-specific science knowledge significantly increases with engagement: an 8% increase with a doubling of the number of active days spent participating (S2). Zooniverse involvement is cited by volunteers as contributing to changes in behaviour, sometimes over very long time scales; e.g. PhD student Samantha Youles cites involvement in Zooniverse projects (2012-2015) as a stimulus to obtain a PhD (S8).

Impact on University and School Teaching

Zooniverse projects are being used in both University teaching and school education. Educational materials based on Zooniverse projects are provided online (<https://classroom.zooniverse.org> and <http://zooteach.org/>). Across the USA, approximately 900 university students interact with Astronomy-related citizen science projects hosted by Zooniverse each year in "Astro101" classes (S9). Two NSF-funded projects have investigated the impact of inclusion of citizen science in Astro 101 classes. In particular Trouille et al created a Classroom Zooniverse portal, through which students and teachers could access citizen science astronomy materials; they describe an increase in understanding of science and how astronomers obtain their data among 725 students in 10 different Astro101 classes who engaged in this programme (S10). Comments from students include "[Analysing] the data taught us how easily scientific data can be manipulated and how important it is to know what data set was used and if any data was excluded in reaching a

conclusion”, and “Through conducting this research project, we found that the nature of science has deep roots in creativity”. (S10)

School pupils are also interacting with the Zooniverse. In 2020, remote learning materials were in demand, with over 4000 views of Zooniverse online learning resources that year (S9). Also in 2020, 900 volunteer hours were provided by 9th-12th grade pupils attending the Regeneron International Science and Engineering Fair (S11). One attendee from Brazil said, “Participating in this experience made me think of other social science issues that I could dedicate myself to.” Zooniverse projects in schools provide an authentic insight into how science gets done, e.g. one teacher reflected that “Galaxy Zoo enables kids to discover how the hard work of real science opens their minds, and makes them curious about their world.” One of her middle school pupils remarked, “Overall, I think that Galaxy Zoo can really help students learn and also helps advance science.” (S12).

Impact on Public Institutions

Museums in both the UK and the USA use Zooniverse materials in a variety of exhibits, bringing Zooniverse projects to a broader audience base that may not engage with online content. In the UK, the Solar Storm Watch Zooniverse project is featured in the Greenwich Observatory Astronomy Exhibit. In the USA, the Adler Planetarium in Chicago has a formal partnership with Zooniverse, through which approximately 50,000 guests to the planetarium per year interact with Zooniverse projects. This has included, from September 2019 to April 2020, a Galaxy Zoo touch table exhibit (for which Masters was a consultant) (S9). Visitors select galaxies and choose which category they fall into, while Adler facilitators are present to explain the research process; participants generate over one thousand classifications per day.

Impact on Researchers: empowering citizen science research

Galaxy Zoo, followed by many Zooniverse projects, has demonstrated the power of citizen science for peer-reviewed research. A next step in our facilitation of citizen science came with the development of Project Builder at Zooniverse.org from 2015, led by a team including Krawczyk in Portsmouth. This online tool simplifies the development of new projects, and has led to an explosion in the number of researchers making use of the platform for their research. As well as the 69 live peer-reviewed Zooniverse projects (12/2020), there are now over 9,000 projects worldwide that have been built on the platform, and more than 300 have collected over 100 classifications each, demonstrating how Project Builder is making citizen science techniques widely available (S7).

Interaction with the public via Zooniverse is causing changes of attitude amongst researchers (S1); e.g. a senior member of the Galaxy Zoo team, Professor Bill Keel (University of Alabama) reflected that “Working with Galaxy Zoo volunteers got me to start posting on submission so they could read it - and as a plus, I often got immediate feedback at least as useful as from a journal referee. So my default has evolved.” (S12). Researchers are learning new ways to interact with the public through the Zooniverse platform; if more volunteer activity is wanted, then two approaches have been found to be necessary (S1): to have more personalised messaging with users who may consider leaving, and to find ways of making tasks appealing through gamification. In this way, interacting with Zooniverse classifiers is impacting researcher behaviour, in two way public engagement.

Changing policy and practice: environment and disaster response

Zooniverse projects, directly supported by Portsmouth, are making an international impact on policy and practice. Two examples are:

(a) **Penguin Watch** (2014-present): in this project, volunteers count penguins in images of South Georgia and the Antarctic Peninsula, to understand their changing population. Krawczyk (Portsmouth) designed the pipeline turning volunteer clicks into penguin counts. The project's evidence, that the penguin population declined in some areas from year to year, was provided to the Government of South Georgia with recommendations for extending the Marine Protected Area (MPA) around the islands. This led (in 2018) to the government announcing a major extension to

Impact case study (REF3)

the MPA of 300,000sq km (S13 &S14), protecting marine habitat from exploitation and preventing further decline of the penguin population.

(b) The **disaster relief** project “Planetary Response Network” asks users to identify where storm damage to human settlements has occurred, by comparing old and new satellite images of particular areas. Krawczyk was responsible for post-processing the satellite images for Zooniverse presentation. Volunteer identifications allowed the rapid creation of damage maps of islands such as Puerto Rico, Dominica and St Thomas, following the Caribbean storms in 2017. The maps enabled disaster response charity Global Rescue to concentrate their relief efforts (S15). Planetary Response Network continues to be developed in readiness for future disasters.

5. Sources to corroborate the impact

(S1) Independent review, “The impacts of Zooniverse: a meta review of the “meta” papers” (Dr Charlotte Thorley, Public Engagement and Involvement Consultant, Feb 2020). Commissioned by University of Portsmouth.

(S2) Science Learning via Participation in Online Citizen Science, Masters K.L., Oh E.Y., Cox J., Simmons B., Lintott C., Graham G., Greenhill A., Holmes K., Journal of Science Communication, Vol. 15, No.3, 20.04.2016, p. 1-33.

(S3) Luczak-Roesch, M., et al. (2014). ‘Why Won’t Aliens Talk to Us? Content and Community Dynamics in Online Citizen Science’. In: Eighth International AAAI Conference on Weblogs and Social Media. (Ann Arbor, Michigan, U.S.A. 1st - 4th June 2014).

<http://www.aaai.org/ocs/index.php/ICWSM/ICWSM14/paper/view/8092>

(S4) Prather, et al (2013). ‘Measuring the Conceptual Understandings of Citizen Scientists Participating in Zooniverse Projects: A First Approach’. Astronomy Education Review 12 (1), 010109, pp. 1–14. DOI: 10.3847/AER2013002.

(S5) “New Visions in Citizen Science”, 2013, Bowser A., Shanley L., Wilson Center.

(S6) Astronomy Magazine Article: “Zooniverse: A Citizen Science Success Story”, Oct 2018 Issue: <http://www.astronomy.com/magazine/2018/09/a-citizen-science-success-story>

(S7) List of Zooniverse statistics from Zooniverse database (Dec 2020), together with Zooniverse completed studies (19/12/20) <https://www.zooniverse.org/about/publications>

(S8) Letter from PhD student Samantha Youles 04/03/2021

(S9) Communication from Laura Trouille, Co-Lead for Zooniverse at Adler Planetarium 5/03/2021.

(S10) “Citizen Science in Astronomy Education”, Trouille L. et al, in “Astronomy Education Vol. 1”, Impey, Buxner et al, 2019, IoP <https://iopscience.iop.org/book/978-0-7503-1723-8>

(S11) “Regeneron ISEF attendees contribute 900 volunteer hours”, Society for Science report, July 2020 <https://www.societyforscience.org/blog/regeneron-isef-attendees-contribute-900-volunteer-hours/>

(S12) Quotations from Zooniverse education blog posts 10/03/2014

(<https://blog.zooniverse.org/tag/thoughts-from-the-classroom/>) and Professor Bill Keel (2019), <https://twitter.com/NGC3314/status/1159931375534739457>

(S13) Zooniverse Penguin Watch results, and references therein,

<https://www.zooniverse.org/projects/penguintom79/penguin-watch/about/results>

(S14) Announcement of South Georgia MPA enhancements <https://www.gov.gs/south-georgia-and-the-south-sandwich-islands-mpa-enhancements/>

(S15) Zooniverse PRN results, and references therein,

<https://www.zooniverse.org/projects/vrooije/planetary-response-network-and-rescue-global-caribbean-storms-2017/about/results>