Institution: Imperial College London

Unit of Assessment: 5 – Biological Sciences

Title of case study: A5-5 Cultural and educational impact of the OneZoom tree of life explorer

Period when the underpinning research was undertaken: 2012-2020

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:**
Dr. James Rosindell	Reader in Biodiversity Theory	2012-present

Period when the claimed impact occurred: 2013 to December 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

Rosindell published the "OneZoom" software for exploring evolutionary trees as a research output. This led to formation of a science communication charity (OneZoom CIO) and a genealogy company (ZoomPast Ltd.), each with the published software at the core of their work. The OneZoom website has attracted over 1.2 million users, impacting upon understanding, learning and participation within schools and universities as well on the way members of the public view biodiversity and evolution. It also impacted upon creativity, culture and society by providing interactive exhibits at eight public institutions including the Australian museum and Darwin and Dinosaurs together attracting 550,000 visitors per annum. OneZoom inspired popular science book graphic materials, including the front cover design, and provided software for digital artwork. OneZoom has played a key role in 21 public facing science communication initiatives including educational walks and science festivals. An end result is increased appreciation of biodiversity and the degree to which it is under threat, including promoting conservation and personal actions to help the environment. ZoomPast Ltd. has an independent user base of 77,000, as well as supporting education in genealogy and appearing at trade shows attended by 38,000 people.

2. Underpinning research (indicative maximum 500 words)

A large branch of research in the subject of evolution is concerned with constructing phylogenetic trees. These trees typically demonstrate the relationships between species and show their evolutionary history and common ancestry. The field has experienced an explosion, both in the number of phylogenetic trees being built and in their size, culminating in 2015 with the publication of the first complete phylogenetic tree with over two million species. There was a major problem however… how could researchers, or anyone, view these large trees after building them? Visualisation tools for scientific data are essential to promote understanding, for communication and to stimulate new research, but all classic visualisation tools were stretched to their technical limits by a few thousand species, let alone the two million or more species that would constitute a complete tree.

Drawing ideas from fractal geometry as well as evolutionary biology, Rosindell proposed an influential and creative solution. The idea was to use a user interface common to geographic mapping software, combined with algorithms related to fractal geometry. This enabled phylogenetic trees of any size to be laid out in an intuitive way on a zoomable canvas. The research involved both innovation of the new concept and solutions to technical barriers that needed to be overcome in order to make the concept usable in reality without performance issues. This research was built on by Wong and Rosindell (2020) who solved further technical challenges related to automated synthesis of evolutionary data at the scale of the complete tree of life, and methods to smoothly visualise all this information to end users in a seamless manner. Rosindell

and Harmon (2012), later supported by Wong and Rosindell (2020) laid out a novel and ambitious vision for the future in the field. This future, now a reality, would incorporate a new visualisation paradigm for scientists, for public engagement and for education, with the potential for modification to solve visualisation problems in unrelated fields. The impacts claimed directly arose from the abovementioned research. Not only did they make use of the concepts from the research, in all cases they used and/or built on open source code published as part of Rosindell and Harmon's (2012) article as well as, in many cases, the follow up work of Wong and Rosindell (2020). As the letters of reference testify there remains no real alternative to use of the OneZoom codebase for a wide range of use cases.

3. References to the research (indicative maximum of six references)

Publications:

- "OneZoom: A Fractal Explorer for the Tree of Life" J Rosindell and L J Harmon (2012) Community page in PLoS Biology Doi:10.1371/journal.pbio.1001406
- "Dynamic visualisation of million-tip trees: the OneZoom project" Y Wong and J Rosindell (2020) BioRxiv https://doi.org/10.1101/2020.10.14.323055

Grants:

- NERC postdoctoral research fellowship "Theory of biodiversity, extinction and habitat change on islands and mainlands" to J Rosindell (£354,178, 2012 - 2014)
- NERC independent research fellowship "Biodiversity theory for understanding the effects of habitat fragmentation at multiple scales" to J Rosindell (£488,022, 2015 - 2019)
- NERC impact acceleration awards to J Rosindell: "Proof of concept development for the 'OneZoom' data visualisation engine" to (£38,929, 2013) and "Further development of the 'OneZoom' big data visualisation engine" to J Rosindell (£26,543, 2014) - this ultimately led to the foundation of ZoomPast Ltd.

4. Details of the impact (indicative maximum 750 words)

Societal Impacts on understanding, learning and participation

The OneZoom research described above provided the basis for founding a Charitable Incorporated Organization (CIO) **[A]**. A major impact of OneZoom CIO has been the website which has attracted over 1.2 million unique users from 229 countries and 25,338 cities around the world since 1st August 2013 **[A]**. Users of the website have commented "*It reignited my awe of evolution from undergraduate days 30 years ago.*" (Daniela) and "*I have learnt so much browsing OneZoom and am ever grateful for this resource*" (Chaitanya). Alice Roberts, Professor of Public Engagement in Science, University of Birmingham wrote "*The best tool I've seen for exploring the tree of life on this planet*" **[A]**.

The activities of OneZoom CIO have been sustained by a novel 'leaf sponsorship' scheme in which members of the public make donations in exchange for their name appearing exclusively on their chosen leaf of the tree of life. 724 leaves have been sponsored by 430 donors since April 2016 (raising nearly £20,000). Around half of these are sponsored as gifts and a select few promote conservation work, such as the WWF on the Giant Panda leaf at the request of one major donor to OneZoom. OneZoom has featured at 21 science outreach events (27th September 2013 to end 2020) including the prestigious Cheltenham Science Festival in 2014, 2015 and 2016 **[A]**. One other noteworthy event was the OneZoom launch presentation in 2017 at the Linnean Society of London, described by a trustee of the society, as "*the most successful event in recent history*", "*The most viewed Meetings and Events page on our website ever*" and "*full to capacity*" with 100 attendees who were "*Ecstatic about sponsoring their favourite species and putting their own little mark on the tree*" **[B]**.

One significant impact of OneZoom has been its role in education around the globe and at a wide range of levels. The website products have been endorsed by 19 different educators and their students **[A]**. For example, one associate professor in biology at Jacksonville state university **[C]** wrote that they "*immediately incorporated this amazing resource in my classes*" noting "*As*

Alabama provides very few resources for k-12 teachers, both in and out of Covid-19, a tool like onezoom.org is priceless.", "*the perfect educational tool for the smartphone age.*" That "*turned overwhelming 'boring' text into the 'aha' moment when students can see the connections*" **[C]**. They have taught approximately 80 students with this resource including two who were pursuing Masters in Education degrees and went on to incorporate OneZoom into their own high school biology courses **[C]**. Comments from students and educators elsewhere include "*Fantastic teaching tool for high schools… for many activities in biology classes from evolution to classification.*" (Lynn, US high school teacher), "*Every moment my students spend exploring OneZoom is time well spent and each of those moments expands to dozens of questions... This should be in every classroom.*" (Tom, Science Tutor) "*I often use OneZoom in my class, the students love it.*" (Jana, Associate Professor, University of Calgary), "*I teach the evolution parts of a huge (>300 students) first year general biology module, and some of the students initially think of evolution only in linear, "March of Progress" terms. OneZoom is a great tool to correct that misapprehension!*" (Louise, Associate Professor of Evolutionary Genetics) and "*Probably my favorite website of all time.*" (Jackson, biology student at LSU Baton Rouge) **[A]**. The Linnean Society of London circulated educational advice packs to schools incorporating OneZoom that were viewed 2000 times **[B]**.

Education impact of the original research spans beyond use of the OneZoom website itself. Many of the museum exhibits that feature OneZoom form the basis for school education programmes. For example, the co-curator of the Darwin and Dinosaurs exhibit wrote "*A large segment of museum visitors are school groups and each museum prepares materials specifically for their local schools, including information hunts, and OneZoom is now (and always will be) part of such programming*" **[D].** One particularly innovative educational event utilising OneZoom is the Ancestor's Trail walk run by Central London Humanists **[E]**. This has been run annually since 2014-2019 (cancelled in 2020 due to COVID) and attracts approximately 100 visitors per annum who spend a day at the event. Visitors walk paths in Epping forest and imagine them representing evolutionary paths on the tree of life with numerous educational and entertaining talks en-route. The Chair of the Central London Humanists wrote that to "*contextualise 4 billion years of the tree's growth, simply wouldn't have been possible for our audience without OneZoom. This was especially important because many of our audience were not academic and OneZoom provided an essential scaffold from which to accelerate their learning.*" The group circulated OneZoom to 15 Somerset schools and to other Humanist, nature conservation and academic organisations internationally. This has included the State University of New York, Halton Peel Humanists near Toronto in Canada and the Novosibirsk State University in Siberia **[E]**.

Societal Impacts on creativity and culture

OneZoom software has been used as an interactive display to enhance understanding and interpretation within eight known museum and gallery exhibitions **[A]**. These include "Beautiful Science" at The British Library in 2014 **[A]**, "Wild planet" at The Australian Museum in Sydney from September 2015 onwards **[F]**, "The Tree of Life" at Harn museum of art, Gainesville, Florida in 2017 **[G]**, and the "Darwin and Dinosaurs" travelling exhibition from September 2019 onwards **[D]**. All these displays have a positive impact on the understanding and awareness of the public about subjects such as evolution, biodiversity and conservation. The Australian Museum writes that the OneZoom display "*has provided the center-piece for engaging the public with important ideas about the tree of life*" that "*has been significant providing the vehicle to unite all the wonderful bits and pieces within the gallery into a coherent story about the tree of life and its value for current and future generations…Without OneZoom, we would not have been able to link-together the 400+ displayed specimens (from giraffes to beetles), and also link-together important ideas about the variety of life, its threats, and its values*" **[F]**. The OneZoom display occupies a central space within the Australian museum that is accessed by most of the museum's 450,000 annual visitors **[F]**. OneZoom is also an "*important*" and "*very popular*" feature of the Darwin and Dinosaurs exhibition, which tours between venues and is currently in Idaho, USA, typically receiving 100,000 visitors per year **[D]**.

The OneZoom software engine has powered a major digital artwork known as "One Tree One Planet" by the late Naziha Mestaoui **[G]**. This artwork is displayed by projection and takes the form of an educational light show with optional audience participation as well as an associated mobile app. The scientists behind the project commented "*As a creative and aesthetically appealing representation of the tree of life, OneZoom has the unique capacity to enable viewers to zoom out for perspective on the whole tree and zoom in to see the details.*" They go on to say that One Tree One Planet is "*absolutely reliant on the OneZoom codebase*"… "*no other alternatives can deliver images, conservation information, and the visual flexibility required*" **[G]**. The One Tree One Planet project was funded with a total of $385,000 from various sources in the USA **[G]**. The artwork is displayed at special events that can be held outside, or inside and have so far been hosted in Gainesville, Atlanta, Green Bay, New York, and Davos together reaching out to thousands of people **[G]** influencing their attitude and awareness about biodiversity and evolution. For example, one 7-year-old participant commented "*I never knew we were all connected*" **[G].**

Graphics produced using OneZoom were used throughout the popular science book "The Ancestor's Tale" (second edition, 2016) by Richard Dawkins and Yan Wong as well as on the front cover in some regions, including the UK. Dawkins comments, "*when we wrote the first edition, OneZoom was not available and we had to fall back on traditional and inadequate methods of representation. Fortunately, when we came to write the second edition, OneZoom was available and we made full use of it*" **[H]**. Dawkins describes OneZoom as "*a magnificent piece of software, a brilliantly intuitive visualisation of the tree of life*" that has "*already contributed significantly to the public understanding of science by making the latest evolutionary trees easily accessible*" **[H]**.

An early Open Source version of OneZoom was developed into software for visualisation of human family history, leading to foundation of a spinout ZoomPast Ltd. on 4 July 2016 **[I]**. ZoomPast Ltd. provides web services to the genealogy community, a large and growing sector of enthusiasts wishing to research and preserve information about their family history and cultural past. ZoomPast has been made accessible via a website that has been accessed by over 77,000 visitors. The site has 6602 registered users who between them maintain family trees connecting over half a million individuals **[I]**. The product has been well received with users commenting "*Groundbreaking program*" (Allan), "*genius idea*" (Sarah and Shelly), "*the best way to explore and visualize your family tree*" (David) and "*Thank you for making it easy*" (Plamer, 7 years old) **[I]**. The ZoomPast website has been used in educational settings too "*Such a user friendly program… great news for my genealogy students*" (Jim) **[I]**. ZoomPast has been displayed at two major trade shows: Who do you think you are live (2016) and RootsTech (2019), which have a combined attendance estimated at 38,000 as a minimum **[I]**. One attendee commented "*the most fascinating product I've seen at RootsTech*". ZoomPast has raised the interest of industry experts with an industry UX designer describing it as "*The most fluid and complete way of displaying a tree*" and the director of a genealogy company stating "*we believe that ZoomPast introduces a new paradigm for exploring data – and especially family tree data*" **[I]**.

Environmental impacts

The end goal for many applications of OneZoom has been to communicate the scope of biodiversity and raise awareness of the degree it is under threat, leading to increased understanding and personal action to reduce impacts on the environment. Indeed, the formally stated aim of OneZoom CIO is to "*provide easy access to scientific knowledge about biodiversity and evolution, and raise awareness about the variety of life on earth together with the need to conserve it*" **[A]**. This occurs in part through the OneZoom website and museum exhibits. "*A brilliant, interactive tool for understanding the scope and scale of the tree of life, including highlights for conservation priorities.*" Prof. Dame Georgina Mace, University College London **[A]**. OneZoom has supported other projects and organisations with more explicit conservation agendas, such as the Zoological Society of London EDGE of Existence programme, which uses the tree of life to inform conservation prioritisation and has supported 113 conservationists and projects across 45 countries for more than 100 EDGE species **[J]**. Head of the Global Conservation Programmes at ZSL writes "*OneZoom was operationally integrated into the EDGE*

of Existence website in 2017, where it provides our users the functionality to explore the broader tree of life", "*OneZoom is a key part of the site's functionality as it allows users to visualize the relationships between different EDGE species, something which would not otherwise be possible*." "*There is no tool quite like it*" **[J]**. OneZoom also featured as part of an EDGE 10th anniversary celebratory series of talks at ZSL attended by over 120 guests **[J]**. The One Tree One Planet artwork and app too specifically encourages end users to take action to help the environment ranging from changes to the foods they choose to eat to the fabrics they choose to wear and the way they spend their leisure time. The app has been downloaded by nearly 2000 people, who have declared pledges to reduce their impacts. The One Tree One Planet project writes "*None of this outreach and education would have been possible without the creative and scientific foundation provided by OneZoom. OneZoom has consequently had a huge positive impact on public engagement with the tree of life and in promoting the importance of biodiversity*.**" [G]**

5. Sources to corroborate the impact (indicative maximum of 10 references)

[A] Letter from OneZoom CIO, UK (All Trustees) - details on charity formation, funding, user quotes, website use data, public facing events, and other impacts.

[B] Letter from Linnean Society of London - collaboration with OneZoom, impact of OneZoom at events and educational use of OneZoom.

[C] Letter from Jacksonville State University, AL, USA - direct educational use.

[D] Letter from Darwin and Dinosaurs exhibition, USA - inclusion of OneZoom.

[E] Letter from Central London Humanists, UK - use of OneZoom as part of Ancestor's Trail educational walks.

[F] Letter from Australian Museum, Sydney - impact of the OneZoom exhibit.

[G] Letter from Florida Museum of Natural History, FL, USA - role of OneZoom as part of One Tree One Planet digital artwork and impacts of that work.

[H] Letter from Richard Dawkins - use of OneZoom in his popular science writing and presentations.

[I] Letter from ZoomPast Ltd., UK - details on company incorporation, public facing events, end users of website, end user endorsements, and commercial interactions.

[J] Letter from Zoological Society of London, UK - science communication around conservation efforts and the ZSL EDGE programme.