



Built to last! Embedding open science principles and practice into European universities

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ABSTRACT

*The purpose of this article is to examine the cultural change needed by universities, as identified by LERU in its report *Open Science and its role in universities: a roadmap for cultural change*.¹ It begins by illustrating the nature of that cultural change. Linked to that transformation is a necessary management change to the way in which organizations perform research. Competition is not the only, or necessarily the best, way to conduct this transformation. Open science brings to the fore the values of collaboration and sharing. Building on a number of Focus on Open Science Workshops held over five years across Europe, the article identifies best practice in changing current research practices, which will then contribute to the culture change necessary to deliver open science. Four case studies, delivered at Focus on Open Science Workshops or other conferences in Europe, illustrate the advances that are being made: the findings of a Workshop on Collaboration and Competition at the OAI 11 meeting in Geneva in June 2019; alternative publishing platforms, exemplified by UCL Press; open data, FAIR data and reproducibility; and a Citizen Science Workshop held at the LIBER Conference in Dublin in June 2019.*

Keywords: *Open Science, Change Management, Open Access Publishing, Research Data Management, Citizen Science, Research Metrics*

*'Stakeholders should be open to open science, preparing for the future, not clinging to the past.'*²

1. Introduction

Open Science as Cultural Change

Open science, that is open research and open scholarship in all disciplines, is a different way of pursuing scholarship. Today, science is carried out in a highly competitive framework. Researchers and organizations compete to promote their scientific assumptions, to win funds, to be the first to discover something or find solutions, and/or to get the best publication space to communicate their success and make their conclusions shine. In this landscape, researchers compete to publish more, compete for attention, and/or compete to win comparative assessments. There is an important observation we should make here: competition is about winning a race where the rules are set by others.

Success is measured by someone else's definition of it. Competition is one important element of human progress, but it is not the only one and it usually works better when it is related to other elements, like collaboration.

The authors of this article started to organize a series of events on open science throughout Europe in 2015. The series is called *Focus on Open Science*,³ with a mission to promote the concept of, values for and best practices in open science to European communities. Each of these events (called chapters) is organized in close collaboration with a local academic institution, in this way determining each year the topics that are most suitable to be discussed within their own open science landscape, but having in mind the overall recommendations on open science from the European Commission (EC). The series started with one chapter in Ljubljana and the team went on to deliver 11 events in 2019.⁴ We reached a number of conclusions during these events and many of them have helped us to orient this opinion piece.

Open science is a different way of conducting research in which collaboration stands right next to competition. This novel route is able to unlock further resources as well as create a more stable, distributed, powerful and sustainable infrastructure that is more efficient than it otherwise might have been. Yes, we do also suggest that funders should look again at the type of research they fund, possibly less oriented to project-based investments. Research investments should match ideas and not the opposite. Great ideas are currently shaped to fit calls for projects and are sacrificed if the competition barometer does not predict success.

In scholarly communication, in particular, which has been transformed from avenues of communication into a network of publication with metrics and analytics, we can see important areas left undeveloped. The results of research are more likely to be published if they are positive. Instead of growing a culture for disseminating the (ultimately important) results of research activity that was conducted rigorously, under a solid methodology which produced important data sets, we have built a system that is doing so only if the results are positive, a system that is pushing for certain areas of exploration that are more likely to win the metrics competition. Editors should not make a decision for publication based on results alone. They should do so based on the rigour of the research process and how the results contribute with all their elements to the field of study: from data sets to algorithms and to conclusions.

We would like to highlight what we consider to be the most fundamental difference between locked science (closed science, where data sets are locked in private archives) and open science. Today, locked science is performed within a highly competitive framework, as described above. Competitive research is tracked numerically; researchers keep making comparisons between colleagues and wanting to win.

Competition is built around the verb 'to have' and increases the sense of ownership. Collaboration is built around the verb 'to be' and, amongst other things, it opens up opportunities for new ways of performance. Combining the principles of competition and collaboration, we can obtain the right level of ownership in research (from knowledge to infrastructure) and the right model for collaborative performance that will ensure recognition and sustainability.

Managing the Open Science Transition

There are many challenges in moving to an open science environment, including copyright, costs, data privacy and so on. However, having met with many relevant players in a diverse range of European research communities, we have noticed that the institutions leading in open science all share the same opinion: the most difficult change needed seems to be cultural change.

As the LERU advice paper on open science, launched in May 2018, strongly suggests, cultures do not change overnight.⁵ A programme of change management needs to accompany and support any move to open science. Universities need to decide which mix of policies, measures and engagements best supports their missions and implementation strategies. Since these vary across Europe, it is impossible to have identical goals across all universities.

European universities, and to an extent most research organizations, admit that one-size-fits-all solutions are in most cases inappropriate and unlikely to be successful, but there will be areas where large groups can work together on shared goals. Such a commitment is enshrined in the LERU advice paper on open science:

'Scholarship is a complex system. Open Science is even more complex. The transition to Open Science affects all stakeholders – universities, researchers, teachers, students, funders, publishers, policy makers and support organizations.

Bringing that Change at Research Organizations Requires

1. Leadership, vision, strategy and adequate resources for implementation,
2. A mix of targeted measures to achieve cultural change,
3. Transparency, accountability and monitoring,
4. Trust and confidence in a shared vision.⁶

The Focus on Open Science Workshops recommend management solutions tailored according to the individual requirements of each institution. What is needed for that?

- Team development: select the right team for the change to transition to open science.

Develop sets of skills for your team, both soft skills (management) and hard skills (Open science). Training programmes are a key element, both for staff and for researchers.

Consider continuous training programmes for researchers, to include newcomers.

- An irreversible change can only be driven by solid and good leadership, outstanding teams with great skills, disciplined thoughts and actions and shared practice.
- Build tools for open science, such as open access (OA) university presses, data repositories where the items are findable, accessible, interoperable and reusable (FAIR),⁷ toolkits for Citizen science etc.
- Lead through actions and not simply through statements.
- Attract resources (in money, staff and time) since a move to open science cannot be made without resource allocation. Such resources can be obtained only if you have a solid strategy and a realistic action plan.

Case Studies

Case Study 1: Competition and Collaboration

The authors of this article organized a workshop at OAI11 in Geneva (21–23 June 2019), an event co-hosted by CERN and the University of Geneva.⁸

This workshop aimed to create stepping-stones for building a path for raising collaboration to the same level as competition in a new definition of success in research. It brought together 15 people from eight countries, with various professions: researchers, research administrators, publishers, librarians and representatives of technology companies.

The meeting started with two short presentations from the authors of this article: one from Dr Tiberius Ignat (Director of Scientific Knowledge Services) and the second from Dr Paul Ayriss (Pro-Vice-Provost, University College London [UCL] Library Services and Fellow of the Royal Historical Society, UK).

The main message of the first presentation was that without a high level of collaboration, open

science is less vibrant, is disadvantaged and is a 'reversible' movement.

Tiberius Ignat also presented his view regarding the hazards of open science. These are:

- Failure itself (i.e. not delivering a radical and positive change, not attracting the world's biggest talents nor nurturing diverse communities of explorers)
- Becoming an exclusive movement of public research that continues to increase the disconnect with society
- Associating 'open' with 'ignore' when it comes to resources that are needed to perform using 'open' methods
- Danger of the lack of reciprocity: where some communities benefit from FAIR data, OA and other research output shared globally, while others use the output thus shared without themselves contributing to the global research commons.

Next, he brought the perspective of misdirection to the fore: that open science is about changing patterns of participation. We have become used to hearing that science should be taken back by public institutions, with a certain preference for not-for-profit organizations. Yet, that is misleading! Limiting participation in research activities to just one part of society (public and not-for-profit) creates unnecessary isolation and increases the gap between public research and the broader society. Instead, the speaker stressed that:

- Great research exists in non-public as well as not-for-profit organizations
- Research should no longer be perceived as an elite activity
- Distributed participation gives far more public control than a concentration on one particular sector.

Instead of looking to limit participation, we should look to increase and distribute both membership and governance. That could make a much bigger difference in the process of opening up research activities to obtain transparency, integrity, long-term support and agile steering.

In Paul Ayris's presentation, the takeaway message that he proposed to the participants was:

- Academically, competition should be against yourself, not really against each other
- No university can be self-sufficient
- Emphasis is on multidisciplinary and interdisciplinary research
- Universities need to partner with society to show their value
- All these principles are underpinned by collaboration.

This presentation showed what collaboration looks like in practice, at a research-intensive institution. Paul Ayris presented an analysis of the 2019 UCL Research Strategy⁹ which contains three references to Competition and 19 equivalents to Collaboration. Among the six principal directions of UCL 2034: a new 20-year strategy for UCL,¹⁰ Principal Theme No. 6 (Delivering global impact)¹¹ is described as 'delivering global impact through our international activities, collaborations and partnerships'. As an example of European engagement, UCL's triple-track European strategy has included consolidating existing partnerships with European universities, launching a new initiative called the Cities Partnerships Programme (starting in Rome and Paris) and stepping up the University's support for EU research collaboration. In terms of national partnerships, UCL was selected in December 2016 to host the research hub and operational headquarters of the UK DRI (UK Dementia Research Institute), forming the focal point for activity across the six university partners of the UK DRI. The other centres are at the University of Cambridge, Cardiff University, the University of Edinburgh, Imperial Col-

lege London and King's College London.

Breakout Groups

The workshop continued with two breakout groups, where the meeting split into teams to try and identify how new goals and new principles could support researchers and research organizations, if we indeed want collaboration to be valued as equally as competition.

Here are the principles and goals that were suggested:

- Share knowledge with the broader society
- Create funding systems that encourage young talents to become researchers. Embed collaboration from the early stages of activity as a long-term strategy
- Make public engagement part of research proposals and a criterion for funding
- Find new resources/extend existing ones to support research ambitions, outside current Templates (channels)
- Funding through projects should not be the only channel for supporting research activities
- Support research programmes more obviously and not simply research projects
- Disseminate outputs (publications, data, software) more broadly.

Debate, Brainstorming and Speed-talk Tables

The last part of the workshop included a debate, a brainstorming session and three speed-talk tables, in an effort to find the first stepping-stones towards a path for more collaboration in research activities.

Here are the ideas that were shaped:

- Collaboration might build more reproducibility into the system and avoid creating a Single point of failure
- Collaboration is a sign of research integrity and should be embedded in institutions and In careers
- Measure the performance of research funders, who should include in their policies Actions towards more collaborations in science and between science and society
- Leadership is a necessary element of redesigning research frameworks, with particular Importance being given to developing the role of collaboration
- Create more stability for research careers. Collaborations could be an important element Of such stability
- Project competitions have the potential for producing great ideas that simply do not fit Into calls for projects. Continue to launch project competitions, but find complementary Routes for funding research ambitions
- A dora-type declaration concerning how research funders should align policies on how they evaluate research and how collaboration plays a role in that evaluation
- Encourage pioneering for bringing collaboration up to the same level as competition
- Define the constitutive elements of collaboration
- Reward collaboration
- The governing bodies of projects/programmes should be multidisciplinary and multisector

- The new landscape should encourage registered reports (that give equal attention to Negative results)
- Science storytelling is important for open science.

Case study 2: UCL Press

UCL Press¹² is the UK's first fully OA university press. It was started in 2015, building on the foundations of earlier commercial press activity. The purpose in refounding the press as an OA press was to offer support for the UCL academic community in publishing their research outputs as OA to help achieve their research objectives. In the UK the OA agenda was and is being driven by research funders such as the Wellcome Trust¹³ (now rebranded as Wellcome) and HEFCE (now part of UK Research and Innovation [UKRI]).¹⁴ UCL, as a global research-intensive university, wanted to develop research platforms which would support UCL's academic activity. Partnership with academics was a prime motivator for the University to invest in systems and processes to support OA publishing.

As CEO of UCL Press, Paul Ayriss decided that it should develop publishing strategies for research monographs, textbooks and journals. The activity and the impact of that work in the areas of research monographs and textbooks are described below.

The commercial business model for research monographs was broken.¹⁵ Traditional publishing models had taken insufficient notice of OA or even digital publishing. Between 2014 and 2016 UCL led the Academic Book of the Future project.¹⁶ The results of this project underlined the continuing importance of the book as a unit of output. 'It seems that the future is likely to be a mixed economy of print, e-versions and networked-enhanced monographs of greater or lesser complexity.' Much confusion, however, existed about the role of OA in this landscape.¹⁷

UCL Press started its OA journey with research monographs and has currently published just over 100 monographs. The most popular platforms on which to access these materials are UCL Discovery,¹⁸ the UCL OA repository, and JSTOR.¹⁹ In terms of the conventional print business model for books, sales over the bookshop counter are falling: 'With sales of monographs falling and the publication of individual titles often based on print sales of 200 or fewer, some now question whether the current model is even viable and for how long.'²⁰

While print copies of published outputs are available from UCL Press as print-on-demand copies, this is not the main form of output. Digital OA copy is the form which is easily the most popular. The UCL Press books are held as PDFs in UCL Discovery and made available via the main platforms listed above, supplemented by other routes. In July 2019 download stats stood at 2,167,470, with print sales at 13,643. The ten most downloaded titles are shown in Table 1.

Title	Publication date	Downloads
The Petrie Museum of Egyptian Archaeology	4 June 2015	48,211
How the World Changed Social Media	29 February 2016	338,615
Social Media in an English Village	29 February 2016	77,584
Textbook of Plastic and Reconstructive Surgery	2 August 2016	65,495
Social Media in Industrial China	13 September 2016	100,262
Conservation of Natural and Cultural Heritage in Kenya	7 October 2016	41,945
Fabricate 2017	3 April 2017	46,771
A Conversation about Healthy Eating	3 July 2017	64,359
Social Theory After the Internet	4 January 2018	57,043
Brexit and Beyond	29 January 2018	77,426

Table 1. Top ten downloads of UCL Press titles (to July 2019)

The download figures speak for themselves. The most downloaded book by far is Professor Danny Miller's *How the World Changed Social Media*.²¹ Miller was awarded a European Research Council grant to look at the impact of social media around the world and his research team has produced a number of books on this theme, for which *How the World Changed Social Media* is the summary volume.

One of the top ten is a textbook: *Textbook of Plastic and Reconstructive Surgery*, edited by Dr Deepak Kalaskar and others. This documents innovative clinical techniques in burns and plastic surgery. In discussion with the lead author, it was clear that he wanted the textbook to be OA in order to share such clinical practice with colleagues in developing countries, who simply would not be able to afford multiple copies of paper textbooks.

Another finding from the UCL Press stats is the debunking of the idea that OA publication kills paper sales. Although not the primary form of dissemination, the Press is still making significant sales of paper copy, for example over 13,000 in July 2019.

These figures debunk another misconception. Mandates for OA publishing from research funders usually exclude research monographs from their remit on the grounds that it is very difficult to change the current book publishing model. This is certainly the view of Plan S²² from Science Europe. Yet, the UCL stats suggest the opposite: that OA research monograph publishing is ripe for development.

At the workshop on research practice held as part of OAI 11 in Geneva, the attendees looked at collaboration and sharing as a complement to traditional models of research competition. The theme of sharing and the creation of a global community being able freely to access

Statistics

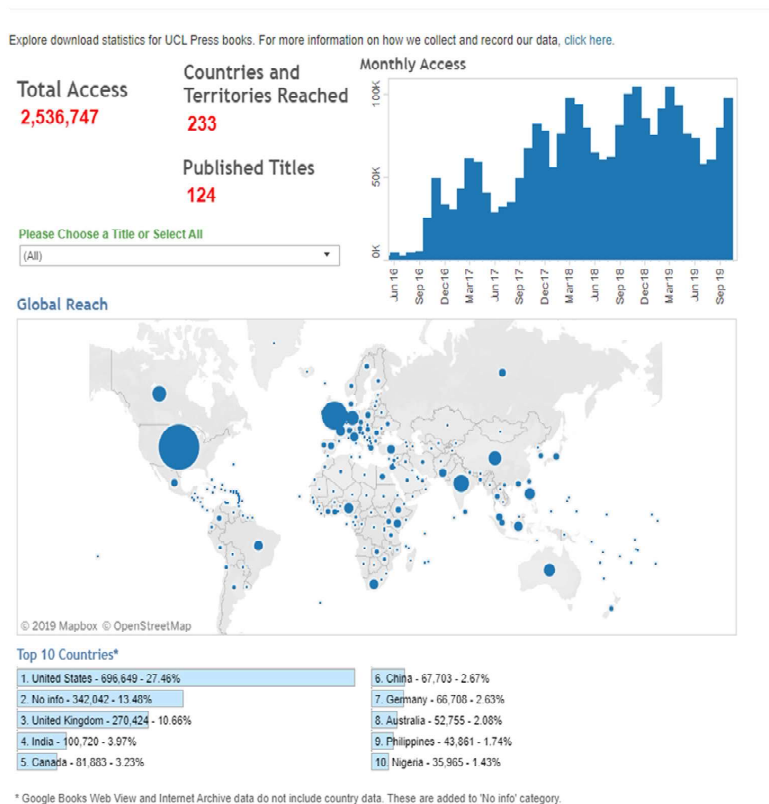


Figure 1. Distribution Map Of UCL Press Downloads (December 2019)

research outputs is fundamental to the values held by UCL Press. Through the activity of the Press, UCL is able to fulfil its strap-line as 'London's Global University' and to act as a generous partner in sharing its research outputs with the world. These are also the same ambitions as UCL's Global Engagement Strategy.²³ The heat map (Figure 1) shows the impact around the world of the downloads of UCL Press titles. Through the model of OA publishing, UCL has been able to reconnect its research activities in a very real way with communities across the globe. By doing so, UCL is able to share its insights to help discover solutions to the ills which face society – such as global warming, poor health and poverty.

UCL has been able to develop its concept of sharing in the publishing arena in one further direction. The Press offers 'white label' publishing services to universities who wish to have their own university press but do not wish to invest in all the infrastructure necessary to deliver it. In this way, UCL Press can provide back-end publishing services to universities who want to become publishers. Front-end services, such as commissioning and peer review are the responsibility of the local university. All published outputs are branded with the name of the local university press. Dublin City University is the first European university to avail itself of these services, becoming the first fully OA university press in Ireland.

Case study 3: Open data, FAIR Data and Reproducibility

LEARN

Research data is the new currency in research activity. A useful set of tools and insights on the role of research data was established by the EC-funded LEARN project,²⁴ which received funding from the European Union's Horizon 2020 research and innovation programme.

LEARN produced a number of important outputs:

- A toolkit of best practice in research data management (rdm)
- A model policy for rdm
- Executive briefing on rdm in six languages
- Key performance indicators
- 20 RDM best practice recommendations
- An evaluation grid for rdm policies in europe
- Core elements of an rdm policy
- An rdm readiness survey data set.

One of the case studies in the toolkit of best practice looked at levels of preparation amongst researchers in a research-intensive university, UCL, for systematic RDM. The case study built on a wider survey undertaken in 2016 by Miriam Fellous-Sigrist on UCL researchers and their research data: practices, challenges and recommendations.²⁵ Question 61 of the survey asked at what stage of their projects researchers started thinking about RDM. Two thirds of those answering (n = 217) said that they thought about this at the beginning or all the time. The answers from the remaining third were less positive. (See Table 2.)

UCL's Research Data Repository (RDR)

Open data is key to establishing sharing and collaboration as part of UCL's research mission. With this in mind, 2019 saw the launch of the Research Data Repository (RDR) for open data – data which is not personal nor sensitive and can be shared with a broader community.²⁶ The position of the RDR in the UCL research system is illustrated in Figure 2.

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The position of the RDR in the UCL research system is illustrated in Figure 2.

Timespan	Defined as:	%
Beginning of the project	'Very early on'; 'straightaway'; 'pre-protocol'; 'at the outset' etc.	51
Always	'All the time'; 'Throughout'	16
Project development	'Proposal writing'; 'for ethical review'; 'planning' etc.	14
Before or after	'data collection' 'Questionnaire design'; 'fieldwork preparation' etc.	4
During the project	'Periodically'; 'halfway through'; '1st year of PhD'	4
Never		4
Late	Also 'Too late'	2
End of project	'At the end'; 'towards the end'	1
Project completion	'Ready for publication'; 'database completion'	1
Ad hoc		1
When a problem occurred		1
'Not until I took this survey'		1

N = 217

Free text answers

Table 2. Results of a UCL survey (2016) on research data management practices (with part percentages rounded up)

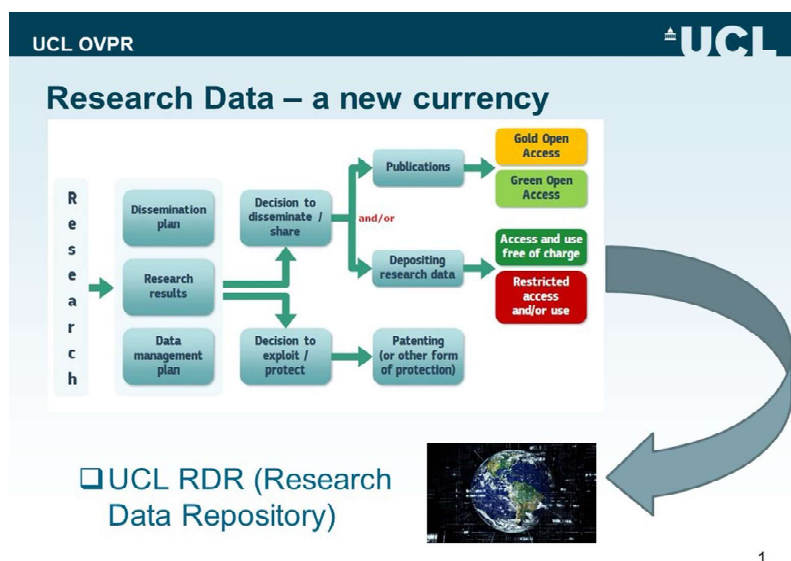
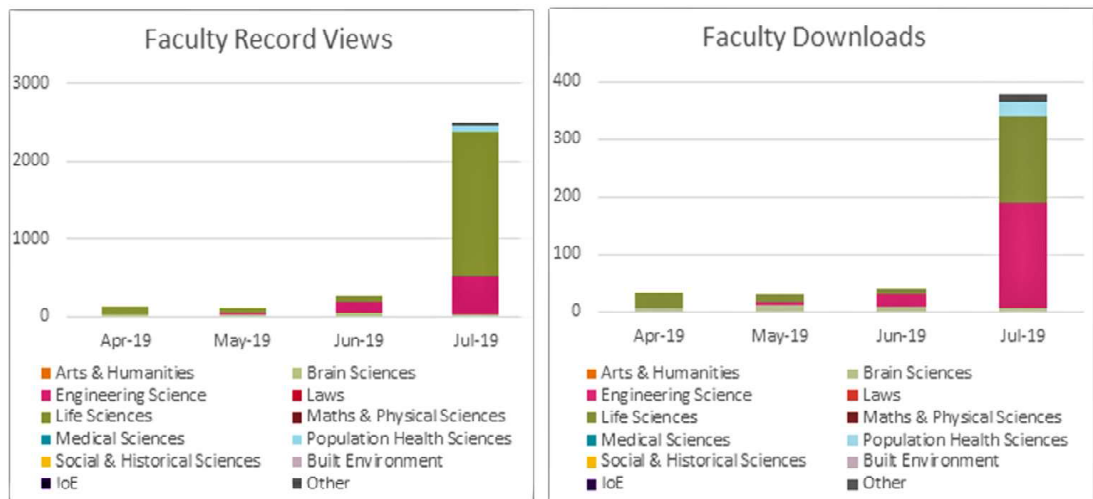


Figure 2. The position of the Research Data Repository in UCL's research system Graphic from H2020 Online Manual²⁷

As Figure 2 shows, publications can be disseminated as green OA outputs via the institutional repository or else made available as gold OA outputs. UCL Press would be one such avenue. The RDR serves the same function for research data, enabling UCL to share its research data assets with the rest of the world.

RDR was launched in June 2019, the culmination of a substantial three-year project. Given the short amount of time that RDR has been live, figures for usage are still in their infancy. Nevertheless, the data so far shows that the launch of RDR has made an impact on the UCL research community. The provision can only grow in importance and visibility as research funders increasingly require data curation plans and mandate curation as a condition of grant funding. Where they require open access to publications, they do not (yet) mandate the same for funded research data. Figures 3a and 3b show the monthly number of views and the number of downloads from RDR broken down by each of the UCL's Faculties and Schools.



Figures 3a and 3b. Charts Showing Views And Downloads Of Research Data From Ucl Rdr²⁸

The RDR service also reports on the global impact RDR is making by analyzing record views per country. Figure 4 shows where users of the RDR are based.

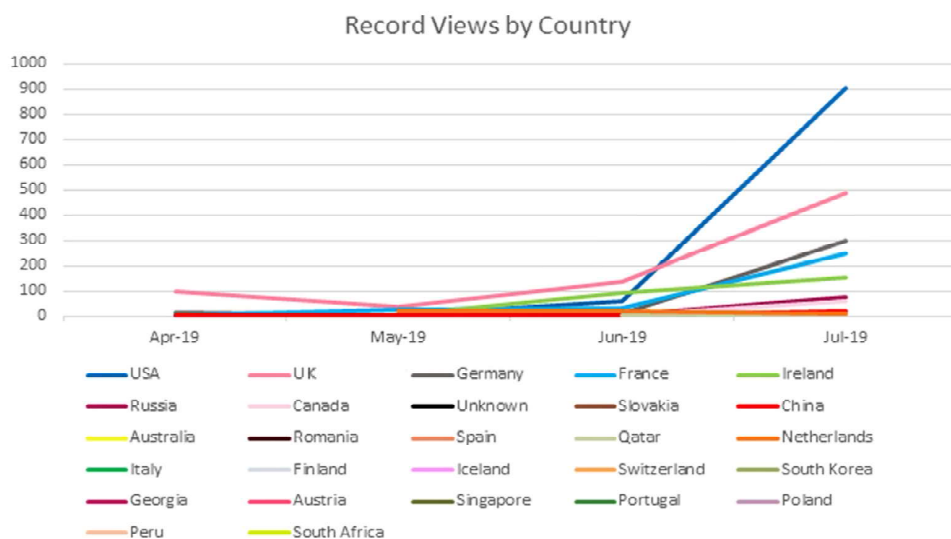


Figure 4. Graph showing record views in RDR by country

The RDR represents a major investment by UCL in open data and is a contribution by one of the world's great research-intensive universities to the open science agenda. It fulfils the aspirations voiced by Professor Geoffrey Boulton in his contribution to the LEARN project, echoing the Accord on Open Data from The International Union of Crystallography:²⁹

*'Publicly funded scientists have a responsibility to contribute to the public good through the creation and communication of new knowledge, of which associated data are intrinsic parts. They should make such data openly available to others as soon as possible after their production in ways that permit them to be re-used and repurposed.'*³⁰

*This is the position adopted by the RDR. Research data should be 'as open as possible, as closed as necessary'.*³¹ It is not a mandate for openness. The decision on whether to make data open lies with the research group undertaking the research, but open approaches are strongly encouraged.

FAIR data

Fundamental to good RDM are the FAIR principles, supporting data that is findable, accessible, interoperable and reusable.³² Most of these principles concern metadata. It should be noted that FAIR data is not the same as open data. Data can be FAIR, but still not open. One of the challenges in implementing FAIR data practices at institutional level is that FAIR demands significant input by researchers to describe their data.

UCL has taken a measured approach in requiring metadata to describe research data in RDR. The web guidance specifies the following points.

- If you do not need to follow a discipline-specific schema, or funder's recommendations, then we advise you to use the DataCite metadata schema.³³
- As a general rule, DataCite³⁴ recommends that your metadata should at least specify:
 - æ% an identifier (a DOI)
 - A Creator (The Name And Affiliation Of The Main Researchers Involved In Producing The Data Set)
 - A Title (The Name Or Title By Which The Data Set Is Known)
 - A Publisher (The Name Of The Entity That Holds The Data Set)
 - A Publication Date (The Year When The Data Set Was Or Will Be Made Publicly Available)
 - The Type Of Resource you are describing.³⁵

FAIR data will underpin the development of the EOSC (the European Open Science Cloud) which is intended to become an 'internet of things'. This point is made forcibly in the EC report Turning FAIR into reality.³⁶ The report makes 27 recommendations, which are grouped into 'priority' and 'supporting' recommendations. The 15 priority recommendations should be considered the initial set of changes or steps to take in order to implement FAIR. Recommendation 10 recognizes the challenge which FAIR principles bring to an institution: 'Steps need to be taken to develop two cohorts of professionals to support FAIR data: data scientists embedded in research projects, and data stewards who will ensure the management and curation of FAIR data.'³⁷ There are significant financial implications behind this recommendation as, initially, there are extra upfront costs that have to be met. It will be a significant challenge for universities to meet. The Report acknowledges this and Recommendation 18 says: 'Research funders should require data management costs and other relevant costs to be considered and included in grant applications where relevant. To support this, detailed guidelines and worked examples of eligible costs for FAIR data should be provided.' However, not all research is grant funded and so the recommendation alone will not deliver a fully FAIR world.³⁸

Recommendation 17 makes an important statement concerning FAIRness and openness: 'Policies should be aligned and consolidated to ensure that publicly-funded research data are made FAIR and Open, except for legitimate restrictions. The maxim "as Open as possible, as closed as necessary" should be applied proportionately with genuine best efforts to share.' This is exactly the position taken by the RDR at UCL.³⁹

Reproducibility

Reproducibility is critical to research in certain contexts, particularly in the experimental sciences with a quantitative focus. It forms part of UCL's wider commitment to transparency and rigour in all of its research. UCL recognizes that behaviours in support of transparency and rigour vary considerably across disciplines and methodologies, and encourages researchers to adopt those actions most appropriate to their disciplines.

In the arts, humanities and social sciences, it may be more useful to refer to transparency or academic rigour in the use of research methods and in the whole research process – from the collection of evidence or thoughts through analysis to final conclusions and the publication of findings.

The reproducibility of research methods is required for research to be replicated. This, in turn, is essential in research contexts where findings must be robust and reproducible in order to form a solid foundation on which to build further knowledge.

In research contexts where reproducibility is possible and appropriate, UCL strongly encourages researchers to use measures that support it. These include (but are not limited to):

- *Pre-registration of research studies*
- *Transparent reporting of research in line with guidelines⁴⁰*
- *Disclosure of all tested conditions, analysed measures and results*
- *Transparency around statistical methods (including sample size planning and statistical Assumptions and pitfalls)*
- *Use of preprints*
- *Carrying out replication studies*
- *Publication of 'null' findings.*

Professor Marcus Munafo and others have set out a summary of initiatives that support reproducibility.⁴¹

UCL is committed to supporting transparency in research and to developing approaches to improve the quality of the research produced. This includes:

- *Continuing to support open research (including through the academic careers*

Framework⁴² and the necessary cultural change, as discussed in Ieru's policy paper⁴³ on open science

- *The development of governance processes to enable research outputs to be found, accessed, and reused appropriately when open sharing is not appropriate*
- *The development of additional training, including in research methods, and consideration Of how to promote transparency in academic teaching*
- *Improving the sharing of knowledge and best practice across ucl.*

In the autumn of 2019 UCL took steps to implement these convictions by issuing a Statement on Transparency in Research, which sets out the expectations the institution has for researchers relating to transparency and reproducibility at UCL.⁴⁴

Case study 3: Citizen Science

Citizen science refers to general public engagement in scientific research activities when citizens actively contribute to science, either with their intellectual effort or surrounding knowledge or with their tools and resources.⁴⁵ In their 2014 white paper, the Societize Consortium describes this scientific activity in which participants provide experimental data and facilities for researchers, raise new questions and co-create a new scientific culture. While they are adding value, volunteers also acquire new learning and skills and gain a deeper understanding of scientific work in appealing ways. As a result of this open, networked and transdisciplinary scenario, science-society-policy interactions are improved, leading in turn to more democratic research based on evidence and informed decisionmaking.

There are several efforts to create a definition for citizen science, one of most recent being proposed by five Austrian authors⁴⁶ which triggered a flurry of online discussion and resulted in the publication of a response pointing to the problem that we have in delineating narrow criteria for citizen science.⁴⁷ We think that certain criteria and tools could be adopted and employed to create a more inviting environment and to provide access and power to those lay people who wish to engage with scientific efforts. At the same time, this approach should offer trustworthy data and further contributions by researchers. For this, scientists and research support organizations need to design new services and processes like training programmes, assessment, and/or compliance tools that assure high-quality public participation in science.

An example of such recommendations to create support for citizen science projects can be found in LIBER's (The Association of European Research Libraries') Roadmap for Open Science.⁴⁸ LIBER recommends designing a triangulation between the library, researchers and the public in which libraries become an active partner that creates support infrastructure enabling responsible conduct and good scholarly practice through guidelines and developing skills for citizen science practitioners.

Citizen science is seen as one of the eight pillars of open science as defined by the Open Science Policy Platform (OSPP) which is one of EC's high-level expert groups. By including it in its definition of open science, OSPP is making a set of recommendations to funders, research performing and research support organizations. Citizen science and all related methodologies should be seen as part of public engagement in science and technology, which is very important for the progress of science. It is opening up new resources for researchers and research organizations. Citizen science also has important roles in developing a scientifically literate society and in providing a solid entry point for people who are not trained as scientists, to support them in suggesting important topics for the research agenda.

Successful citizen science projects involve the public from the early stages of research and communicate with the general population about the progress that is being made at the frontiers of knowledge. Managing the transition to a new culture of open science means, from the perspective of citizen science, seeing a public contribution not only in the area of enhancing scientific effort (by collecting data, being involved in public outreach, etc.), but also in addressing societal needs by creating scientific evidence that supports public decision-making. In this way, citizen science can contribute to the education of the general population and increase society's scientific literacy by developing networks of professionals and amateurs that can accelerate discovery.

The quality of data in citizen science projects remains an important element to be managed in the new landscape of open science. There is enough evidence to show that, with the right training programmes, the data collected by citizens passes quality control at expected levels.

One example in which training played an important role is Capturing our Coast (CoCoast),⁴⁹ a project which trained over 3,000 volunteers (between 2015–2018) to gather data to help

scientists understand in more detail the species that live on UK coasts. As an interesting fact, the volunteers in this project have produced the first record of a *Xaiva biguttata* crab in the UK since 1956.

Another project that involved a great number of volunteers and in which 90% of the data passed quality control is Curieuze Neuzen.⁵⁰ This project shows another determinant factor of success for citizen science projects: disseminator power. With over 56,000 registered volunteers, around 20,000 sensors were distributed in the Flemish region of Belgium to monitor air quality. For disseminating this number of sensors, the project partnered with a local newspaper which undertook the distribution of measurement kits.⁵¹

The impact of citizen science is measurable, and it is probably more diverse than traditional scientific methods. Here are two examples, to illustrate the footprint of citizen science in society.

Firstly, researchers at the University of Washington in the USA quantified the value of citizen science activities in biodiversity fields.⁵² They surveyed 388 US projects and found that the projects embraced 1.3–2.3 million citizen scientists, who provided US\$667 million–2.5 billion worth of in-kind contributions to those projects, annually. The economic worth of citizen science is enormous.

Secondly, Transcribe Bentham (an award-winning⁵³ participatory initiative launched in 2010 at UCL), which engages the public in the online transcription of Jeremy Bentham’s work, has been cited so far in 39 monograph chapters or articles and 13 books.⁵⁴ Peerreviewed scholarly communication is a natural part of citizen science which is also opening additional communication opportunities in lay language for society as a whole. The latter, a separate dimen-

Name	Description	Significance
The European Association of European Research Libraries (LIBER)'s Open science Roadmap ⁵⁵	This Open Science Roadmap was established by LIBER in 2018. Recommendations from this roadmap broadly endorse libraries as partners in citizen science, guiding the development of the field.	This roadmap emphasizes the importance of citizen science as part of cultural change.
LIBER Citizen Science Working Group ⁵⁶	Launched in March 2019, the working group is intended to explore, among other questions, what the role of libraries will be in terms of citizen development, education, and instruction, especially relating to citizen science.	This working group is intended to connect colleagues across Europe to explore citizen science opportunities and best practices.
The League of European Research Universities (LERU)	Comprises over 23 research-intensive European universities. They published a paper ⁵⁷ that analysed trends in citizen science and provided guidelines that ranged from raising awareness to developing assessments for citizen science in research funding and evaluation processes.	Demonstrates institutional support for citizen science at the university level.
Science Europe	Released a briefing paper on citizen science in 2018, ⁵⁸ endorsing the 10 key principles of citizen science developed by the 'Sharing best practice and building capacity' Working Group of the European Citizen science Association. ⁵⁹	Represents major research funding and research performing organizations across Europe.

Table 3. Examples of European policy-making support for citizen science 2018–2019

sion of science communication, is very important now for consolidating a place for science in an era when expert opinion is targeted/ignored by populist discourse.

For these reasons alone, European institutions are taking citizen science seriously. Table 3 provides examples of European policy-making support for citizen science. The next step is to develop and support implementation programmes and to create rewards for scientific activities that produce engagement with the public.

LIBER took a leading role in creating support services for citizen science at the library level by establishing a working group dedicated to this area of open science. This working group has several goals:

- **Goal 1:** To initiate and/or participate in one research project by October 2021
- **Goal 2:** To staff the working group until the liber conference 2020
- **Goal 3:** To sign two partnerships with outside organizations by October 2021
- **Goal 4:** To deliver by June 2020 a template (or a suite of templates) with accompanying advocacy for a 'single citizen science contact point' that could be implemented in research libraries
- **Goal 5:** To organize and deliver a webinar by July 2020
- **Goal 6:** To create a librarian's guide to citizen science, building on the similar guide created by SciStarter and the State University of Arizona, by July 2020.

These goals will be followed through six strategic directions, which are:

- Projects – referring to goal 1
- Staff development (recruitment, training and skills) – referring to goal 2
- Partnerships and participation – referring to goal 3
- Building citizen science infrastructure in libraries (building a template for single citizen Science contact points) – referring to goal 4
- Advocacy and policy – referring to goal 5 and goal 6
- Creating a librarian's guide to citizen science, referring to goal 6.

LIBER's initiative is in line with the efforts of Arizona State University and SciStarter (an online citizen science hub), which jointly created the Librarian's Guide to Citizen Science,⁶⁰ giving practical guidance to interested institutions. This guide is just one outcome of an ongoing project in the USA entitled 'Libraries as Community Hubs for Citizen Science', which demonstrates the potential for libraries as partners in the citizen science field. The project team includes SciStarter, Arizona State University faculty, researchers, practitioners and evaluators, librarians/staff, citizen science project leaders, web designers/developers and advisors. They collaborated to:

- Develop and evaluate citizen science toolkits available for and through the public library Partners
- Create associated resources to train, support and communicate with librarians and Citizen scientists.

A practical way to approach citizen science at institutional level is by establishing a single citizen science point of contact, a recommendation which is also highlighted in the aforemen

tioned leru roadmap for open science. We propose an attractive name for such points of contacts in order to make them familiar among researchers, the public and other staff: *Bespoc* (broad engagement in science, point of contact). A *bespoc* could typically provide:

- A platform on which to build and continuously update the institutional policy for citizen Science, including a concordat of interest between involved stakeholders (laboratories, Pr offices, safety compliance offices, scholarly communication offices, data centres, Training centres, etc.)
- Information about citizen science activities in the respective institution
- Partnership frameworks between units and departments belonging to the respective institution or with third party organizations
- Collection of templates for citizen science activities (data sheets, protocols, training methods, checklists, reports, evaluation forms, etc.)
- Entry points and dissemination points for scholarly and lay communications, in relation to an institution's scientific activity
- Information about community-building activities
- A point of reference to help scientists embed citizen science into grant proposals
- A gateway for the public to propose research projects.

An example of a strategy that embeds citizen science activities at institutional level, opening the possibility of establishing a virtual BESPOC, is the UCL Library Services Strategy 2019–22.⁶¹ UCL Library Services has identified key priorities for citizen science activity and plans to embed these in a pan-UCL programme. Outreach activities to new communities should become embedded in the life of the Library; and citizen science is a new outreach activity, where the citizen engages with research agendas. One of the key actions of this strategy is to create a virtual Office for Open Science, where a BESPOC could be placed.

Conclusion

The main conclusion of this article is that if research organizations can support collaboration alongside competition as part of their research activity, benefits will follow. Open science is a means by which collaboration, sharing and openness can be embedded into research activities. A move to embrace open science requires a culture change at the institutional level and a series of actions to deliver that change.

This article has looked at four areas of open science and identified case studies of best practice where change is happening:

- Competition and collaboration
- UCL Press as an alternative OA publishing platform
- Open data, fair data and reproducibility
- Citizen science.

The case study on UCL Press shows the impact which full OA publishing can make, embracing areas such as the arts and humanities, with very significant benefits. Research data is the new currency in an open science landscape. To encourage researchers to share their data, making it open where possible, institutions can create their own curation platforms which enable this sharing to take place. Reproducibility and transparency are important elements of research integrity in open science, and UCL has underlined its commitment to such values by issuing its Statement of Reproducibility and Transparency. The final case study is on citizen science, and it

is clear that a number of leading European organizations who have embraced the concept are now working to deliver citizen science solutions for this vital aspect of societal engagement.

Open science is a new way in which research is performed, evaluated, rewarded, disseminated and curated. Europe is playing a leading role in advocating for open science practices and platforms. Such work needs to continue to deliver the transformation and benefits that open science promises.

Acknowledgements

The EC-funded LEARN project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 654139.

Abbreviations and Acronyms

A list of the abbreviations and acronyms used in this and other Insights articles can be accessed here – click on the URL below and then select the 'full list of industry A&As' link: <http://www.uksg.org/publications#aa>

Competing Interests

Tiberius Ignat is the director of Scientific Knowledge Services and he acted in 2019 as an unpaid member of the organization committee for OAI 11, a CERN-University of Geneva workshop. He is also a member of LIBER Citizen Science Working Group where he leads the 3rd Strategic Direction ('Partnerships'). Scientific Knowledge Services offers, on request, consultancy related to open science and Tiberius Ignat might take assignments in that sense.

Paul Ayris is Pro-Vice-Provost (UCL Library Services) in charge of the UCL family of libraries and responsible for the development of open science principles and practice across UCL. He is also CEO of UCL Press, the UK's first fully OA university press. He is co-chair of the LERU INFO community, and chaired the writing committee for the LERU Roadmap for Open Science. He chaired the Scientific Committee for the OAI 11 meeting (2019) of the Cern-Unige workshop on innovations in scholarly communication. He is also the former President of LIBER and currently chairs the LIBER Citizen Science Working Group. All these roles outside UCL are pro bono and are unremunerated. He was also principal investigator for the EC-funded LEARN project on RDM.

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