



PUSHING
THE FRONTIERS
OF INNOVATIVE
RESEARCH

ADVICE PAPER
No.24 - MAY 2018

Open Science and its role in universities: A roadmap for cultural change

LEAGUE OF EUROPEAN RESEARCH UNIVERSITIES

University of Amsterdam • Universitat de Barcelona • University of Cambridge • University of Copenhagen • Trinity College Dublin •
University of Edinburgh • University of Freiburg • Université de Genève • Universität Heidelberg • University of Helsinki •
Universiteit Leiden • KU Leuven • Imperial College London • University College London • Lund University • University of Milan •
Ludwig-Maximilians-Universität München • University of Oxford • Sorbonne University • Université Paris-Sud •
University of Strasbourg • Utrecht University • University of Zurich

Executive summary

Open Science, perhaps more properly termed Open Scholarship in English, represents a culture change in the way stakeholders in the research, education and knowledge exchange communities create, store, share and deliver the outputs of their activity. For universities and other stakeholders to embrace Open Science principles, policies and practices, there needs to be a culture change in these organisations if this transition is to be successfully negotiated. Section I of this paper sets out the nature of that cultural change for universities, suggesting ways in which change can be successfully embedded in organisations and what has to happen to effect that vital change. There are challenges, which the paper identifies, which mean that this transition will not be straightforward to deliver.

Section II discusses the eight pillars of Open Science identified by the European Commission:¹ the future of scholarly publishing, FAIR data, the European Open Science Cloud, education and skills, rewards and incentives, next-generation metrics ('Altmetrics'), research integrity and citizen science. It analyses what the introduction of Open Science approaches means at university level in each of these eight themed areas and identifies the benefits which accrue to the individual academic, the institution, the user of research/educational outputs and to other stakeholders in the research/educational chain. Research funders have a particular role to play in working with institutions to bring about such fundamental change. For each of the eight Open Science areas, recommendations about what universities can do are formulated. Whilst they have been developed on the basis of LERU universities' experience, the recommendations are relevant to universities across the globe and can serve as a roadmap in their journey to embrace Open Science. Evidently, they imply a broader supportive environment and productive interactions with external stakeholders, too.

Section II identifies real challenges in universities embracing Open Science principles and values. How willing are individual researchers to move from traditional models and practices to new systems and values which are to a large extent untried and untested over time? Consider the theme of scholarly publishing. To what extent will writers of research monographs accept Open Access to such products as the future publication model? Do individual journal titles have a future, or are research platforms such as Wellcome Open Research² the future of scholarly publishing in those disciplines where the article is the main form of research output? How should such outputs be evaluated? Do traditional metrics work in an open environment? Are open approaches recognised in evaluation systems, such as academic promotion? How is the cost of doing Open Science calculated and who pays for what? These are all questions which any move to an Open Science system and values poses.

The paper offers a set of high level conclusions in section III, which underline the value of Open Science approaches, but also indicate the profound challenges in any such development. A transition to Open Science is a process, not a single event. Such a transition will take years to effect, not months or days. To transition at the institutional level, we suggest universities should develop a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings. Universities can establish advocacy programmes, which should identify the benefits of Open Science approaches, whilst being realistic about the challenges. They may wish to draw up a communication strategy, which enables the whole university body to become familiar with Open Science practices, and they may want to appoint a senior manager to lead Open Science approaches across all eight pillars of Open Science.

In a first appendix all 41 recommendations in each of the eight areas are grouped together for easy reference. Open Science represents a complex and multi-dimensional process of transition, different for every university. The recommendations in this LERU paper do not represent a prioritisation of topics, nor an exhaustive list of actions to be taken by universities. They, and the paper as a whole, are intended to serve as a roadmap to accompany universities' efforts towards Open Science, leaving room for each institution to carve out its own path, strategy and actions.

In a second appendix a set of 37 questions is provided, which universities can use to measure their progress in implementing Open Science approaches institutionally. These questions can be used iteratively over a period of time to measure a university's growth in Open Science activity and any remaining challenges.

1 Collected from European Commission – Open Science: <https://ec.europa.eu/research/openscience/index.cfm>; last accessed 2 May 2018.

2 Wellcome Open Research: <https://wellcomeopenresearch.org/>; last accessed 17 April 2018.

Open Science: Opportunities, challenges and cultural change in universities

Open Science is not about dogma; it is about greater efficiency and productivity, more transparency and a better response to interdisciplinary research needs

Open Science is a “movement which aims to make scientific research, data and dissemination accessible to all levels of an inquiring society”.³ On the continent of Europe, the movement is more commonly called Open Science. In truth, Open Scholarship is a better title because in English the word ‘Science’ covers just a sub-set of all academic disciplines. The phrase Open Science is retained throughout this paper, as this is the description used by the European Commission. In using this phrase, however, it should be stressed that *all* academic disciplines fall within its purview. In the chapters which follow, the eight pillars of Open Science (as defined by the European Commission) are used as exemplars of the potential impact of this movement in European universities. These eight themes are all inter-related and LERU views them as an inter-linked set of activities which *together* contribute to the Open Science agenda.

There are a number of reasons why there is an emphasis on Open Science now. The prevalence of digital delivery and the omnipresence of the internet means that new ways of doing things are possible. There are other drivers. A perceived disjoint between universities and Society has led many universities individually to investigate new ways of engaging with the general public. The prevalence of ‘fake news’ and society’s distrust of expert opinion underlines the need for universities to make themselves even more open and relevant to Society.

There are important policy drivers too, and the European Commission has made Open Science a priority. Together with “Open Innovation” and “Open to the World”, Open Science is one of the three goals set by Commissioner Moedas for EU research and innovation policy during his mandate (European Commission, 2016). Speaking at the ERA Conference ‘A new start for Europe: Opening up to an ERA of Innovation’ in Brussels in June 2015, Commissioner Moedas (Research, Science and Innovation) highlighted

the importance of Open Science where “new knowledge is created through global collaborations involving thousands of people from across the world and from all walks of life”. The Commissioner therefore called for drawing up “a new path for European research and innovation policy”, fit for an open, digital and global environment (Moedas, 2015). The guidelines in the revised Recommendation on access to and preservation of scientific information -published in April 2018 by the European Commission- support EU Member States in transition to Open Science (European Commission, 2018).

Open Science opens up new ways in which research/ education/innovation are undertaken, archived and curated, and disseminated across the globe. Open Science is not about dogma *per se*; it is about greater efficiency and productivity, more transparency and a better response to interdisciplinary research needs. All this can have a profound impact on universities because, to deliver Open Science, both universities and university researchers should develop new perspectives. To embrace Open Science, universities and researchers need to embrace cultural change in the way they work, plan and operate. The result will infuse a culture of Open Science throughout the academic organisation and may support other evolutions in academic practice, such as the use of next-generation metrics in the evaluation of research output.

Implementation of Open Science is key: Neither the European Commission nor university organisations can be complacent. The need now is for action, not words

The Amsterdam Call for Action emanated from the input of many participating experts and stakeholders in the Amsterdam Conference ‘Open Science – From Vision to Action’, hosted by the Netherlands’ EU Presidency on 4 and 5 April 2016. The Amsterdam Call for Action establishes two major goals, namely that full Open Access for all publicly-funded scientific publications should be achieved by 2020, and that open data – the sharing and re-use of data – should be the standard, where possible, for all publicly-funded

3 FOSTER: <https://www.fosteropenscience.eu/foster-taxonomy/open-science>; last accessed 12 February 2018.

How does Open Science work for the researcher?

Open Science looks at all aspects of the workflow in, say, research or education and identifies which processes would be better performed if they were Open. So, in the writing of an article or a book, an Open approach could look like this:

1. Make the resulting output, book or article, available as an Open Access output under an appropriate licence, ideally one of the Creative Commons licences.
2. Make the underlying research data, certainly the data used in the publication, available as an open dataset so that the conclusions reached in the publication can be checked and verified.
3. Make the research software, used for analysis, available so that the research is reproducible.
4. During the course of the research, consider making both the underlying research data and the publication available, the latter perhaps as a Green Open Access pre-print in a subject or institutional repository at each stage of the editing and review cycle prior to publication.
5. Of course, the activity in step 4 may not always be possible. For example, researchers may wish to retain primary use of their data until they have finished the round of publications which are to be based upon it. However, even in these cases, the actual processed data used in each publication could be made available as an open dataset.
6. In the publication and opening up of the supporting research data, it is highly desirable that a number of standard identifiers/processes be used to help discoverability and re-use of open outputs – ORCID⁴ to identify the authors; FundRef⁵, a common taxonomy of research funder names; DOIs⁶ to identify and locate publications; DataCite⁷ to identify and locate datasets; Open Citations⁸, a movement to promote the unrestricted availability of scholarly citation data, and to make these data available.

The benefits of Open Science

The workflow in the example outlined above is very different from the way many researchers work at the moment and represents a fundamental change in academic culture. What are the benefits of openness? While the following list is not exhaustive, a number of benefits can be identified when analysing the workflow described above:

1. The visibility of all research outputs will be increased once they are open. This should lead to a citation advantage, as users who can easily download open versions of outputs will cite these versions as everyone with an Internet connection will have access
2. Making the underlying research data and methodology available allows individual users to replicate the results of the original authors, and to spot any errors/slips. This level of transparency is good for researchers and good for research
3. Pursuing the steps above will add to the visibility of the outputs and also allow readers to see how the text/conclusions have evolved at different stages in the process
4. As a minimum, research data used in the publication should be made available as a supporting dataset
5. The use of recognised identifiers/processes gives due acknowledgement to authors and external funders and improves citation analysis. It rewards all stakeholders in the research process and enriches the research landscape as a result

4 ORCID: <https://orcid.org/>; last accessed 24 May 2018.

5 Crossref Funder Registry: <https://www.crossref.org/services/funder-registry/>; last accessed 20 May 2018.

6 DOIs: <https://www.doi.org/>; last accessed 7 April 2018.

7 DataCite: <https://www.datacite.org/>; last accessed 2 May 2018.

8 Open Citations: <http://opencitations.net/>; last accessed 22 May 2018.

research. In order for these goals to be achieved, universities should align their assessment, reward and evaluation systems with Open Science developments.⁹

In May 2016, the Council adopted Conclusions on 'The transition toward an Open Science system', calling 'on the Commission, the Member States and the stakeholders to take the necessary actions needed for making open science a reality' (Council of the European Union, 2016). Earlier that year, the European Commission had set up an Open Science Policy Platform¹⁰ (OSPP) to develop policy and to turn it into practice and identified eight pillars which underpin its definition of Open Science. Several expert and working groups have been created so as to examine the eight topics and formulate recommendations.¹¹ The eight pillars below illustrate the broad scope of Open Science and that multiple groups within the university need to contribute towards implementation. Implementation, indeed, is the key and neither the Commission nor university organisations can be complacent. The need now is for action, not words.

Future of Scholarly Communication
EOSC (European Open Science Cloud)
FAIR Data
Skills
Research Integrity
Rewards
Altmetrics
Citizen Science

Source: European Commission

By developing a roadmap for universities, with implications for other stakeholders such as governments and research funders, LERU wants to stimulate real change in Open Science approaches

LERU has already published several papers which examine and make recommendations on aspects of the Open Science agenda.¹² LERU, as a grouping of research-led universities, has a mission to lead by example. With this new paper

LERU wishes to stimulate real change in Open Science, both at universities and elsewhere. It does so by elaborating a comprehensive vision for Open Science from the perspective of some of Europe's leading research-intensive universities. The paper examines what LERU universities and others are doing, can or should do to embed Open Science and its various dimensions in their policies and practices as a way of changing culture. Conceived as a roadmap, the paper sets out what the destinations are for universities' Open Science ambitions. It formulates recommendations for universities and research institutions, but also for other stakeholders, such as funders and policymakers, because change is not only required at universities. Particularly important is the role of research funders. Their decisions and policies are fundamental for creating the momentum towards openness. The German Research Foundation (DFG), for example, funds actions on Open Science within its joint research projects and expects publications in open access formats. Within Research Training Groups they require training courses on the collection, storage, editing and sustainable provision of research data for doctoral researchers.¹³ All stakeholders need to be committed to change for Open Science to become embedded.

Successful engagement with Open Science requires a holistic vision by the institution, working together to deliver a set of goals in a complex and evolving mix of themes and priorities, to which all members can commit

For research performing organisations such as universities, Open Science represents both challenges but also significant opportunities. It is important that universities identify the goals they wish to achieve and the methods by which success can be delivered. Academic, administrative and cultural issues need to be taken into account. These include legal issues, e.g. advice on licensing and copyright issues. A key concern will be costs to the institution. In this paper, costs for particular developments are identified as exemplar costs to guide decision making.

Universities are well placed to undertake a series of actions

9 Amsterdam Call for Action: <https://www.government.nl/documents/reports/2016/04/04/amsterdam-call-for-action-on-open-science>; last accessed 12 February 2018.

10 Open Science Policy Platform: <https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform>; last accessed 12 February 2018.

11 At the time of writing (May 2018), there are reports on the European Open Science Cloud, Rewards, Skills, Next-Generation Metrics and Open Science Publishing. The OSPP will be producing consolidated recommendations on all the eight areas identified above.

12 These are on Open Access (LERU, 2011), Research Data Management (LERU, 2013), Citizen Science (LERU, 2016c), and academic careers (2018b).

13 German Research Foundation: http://www.dfg.de/formulare/54_07/54_07_en.pdf; last accessed 2 May 2018.

which will together help to effect the necessary transformation to deliver the change in culture which will deliver Open Science.

Policy development is crucial and the university can draw up either a single policy covering the various areas of Open Science; or, more likely, an overarching policy or statement on the commitment of the university to Open Science approaches, accompanied by individual policies on each area of Open Science, which advocate an Open Science approach. Individual policies might be needed in each of the eight areas of Open Science outlined in this paper. Some of these might update existing policy statements, for example in the area of Open Access where many universities already have such statements. Other areas will require completely new policies, for example in the area of bibliometrics where, as the chapter on next-generation metrics below shows, the principles of the San Francisco Declaration on Research Assessment (DORA)¹⁴ and the Leiden Manifesto¹⁵ provide a useful framework for universities developing such policies. Governance is an issue which all universities embracing Open Science practices will want to consider. How is such a university-wide approach to Open Science to be managed? Some universities may wish to nominate an individual at a senior level to be Open Science Coordinator. In some countries, such coordinators could work with national coordinators for Open Science. In the Netherlands, the steering group of the National Platform Open Science has appointed former Delft University of Technology Rector Karel Luyben as the National Coordinator for Open Science.¹⁶

Governance at university level may well be conducted by means of a pan-university committee, working with the Open Science coordinator. A university equivalent of the European Commission's Open Science Policy Platform is a vehicle by which all the component parts of the Open Science agenda can be studied from the point of view of policy development, strategy and implementation. Such a high-level committee would be a vehicle for liaison with other university committees which have dedicated remits such as HR or IT, the purpose of such contact being to ensure that Open Science principles are adopted and implemented in specific university policies and activities.

Policy development and governance are an important part of

a university's activities in the area of Open Science.

However, by themselves they will not deliver the change in culture which Open Science requires. Alongside such activities, there are a range of issues where the university can help facilitate the required change. Here the university should work in partnership with members of staff in a mutually supportive dialogue and series of actions which will together deliver the cultural change required to embrace Open Science approaches in the institution. This is a vision of the whole institution working together to deliver a set of goals which all members embrace and to which they are committed.

Universities will also wish to address perceived gaps in their Open Science provision and plans. The European Commission has identified eight component parts of Open Science, but universities may feel that there are additional areas that should be catered for. Copyright regimes allied to Open Science principles, infrastructure development, sustainable research software, open education, and artificial intelligence are examples of areas which are not explicitly treated in the Commission's vision. Open Science is therefore not a series of static issues, but a complex mix of themes and topics yet to be identified. Universities will need to ensure that they are fully informed on the potential impacts of Open Science as the concept develops.

Bringing about change at universities 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, and 4/ trust and confidence in a shared vision

To embed openness in the way universities, academics and students work requires a cultural change in the way each member of Society operates. In part, cultural change can be delivered by the development of policies, strategies and the evaluation of work and outputs against open criteria. However, cultural change requires more than a series of actions. Change can only take place where there is trust, collaboration and commitment to a shared vision for the future. Arguably, the latter is a greater challenge to achieve than the former.

14 Declaration On Research Assessment (DORA): <http://www.ascb.org/dora/>; last accessed 24 May 2018.

15 Leiden Manifesto for Research Metrics: <http://www.leidenmanifesto.org/>; last accessed 24 May 2018.

16 National Plan Open Science: <https://www.openscience.nl/en/press-release>; last accessed 12 February 2018.

17 For a practical example in the field of digital education, see Ehlers, U., Schneckenberg, D. (eds) (2010). *Changing Cultures in Higher Education: Moving Ahead to Future Learning* (Berlin: Springer).

Nonetheless, it is only where all stakeholders work together, building a trusted community, and developing policies and strategies agreed by all parties that true change can become embedded in organisations and research communities.¹⁷

First, realising change successfully requires leadership, vision, strategy and adequate resources for implementation. Leaders should work with the community to explain why change is necessary and to support change, while upholding the principles of excellence and community building advocated by the university.

Second, to achieve change, universities can and should develop and implement targeted measures to help spread Open Science throughout the organisation. Universities should select the right mix of measures in accordance with their institutional, national and other situations. Measures can be directed at some or all of the eight Open Science dimensions identified by the European Commission, or others. They should aim to achieve structural and cultural change at the university. To ensure buy-in, any measures adopted should explain the benefits for individual researchers and their subject areas. Change is a 2-way process where new developments serve to support and develop researcher behaviour, leading to agreed changes of practice.

Third, to ensure effective implementation across the institution, transparency, accountability and monitoring are crucial. Policies and actions should be clearly described and communicated. In complex and multi-layered organisations such as universities, accountability must be given and taken at all organisational levels. Monitoring Open Science is necessary for the university to measure progress on the road to Open Scholarship and to benchmark itself against other organisations. Italy has taken a lead in this area where the University of Milan publishes an annual report each year on Open Science achievements.¹⁸

Fourth, there needs to be trust and confidence in a shared vision between university decision makers, academics and students. Change will not become embedded unless all stakeholders in the institution are confident enough to work together on the journey towards Open Science. Change is not a top-down activity, imposed by the university on its members. For Open Science to flourish, there needs to be partnership with dialogue and consultation to achieve mutually-agreed goals.

Universities need to be able to decide which mix of policy decisions, measures and ways to engage with stakeholders best fulfils their needs in view of the institutions' overall strategies and national or other agendas. Since these vary widely across Europe, it is impossible to have identical goals or measures across all universities, even within the group of LERU universities. 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. This paper contains many examples of and references to LERU universities' policies and initiatives, which are shared as a source of innovative practice and inspiration for universities and other interested parties.

Building on the academic concept of cultural change, Dr Catriona MacCallum (Director of Open Science, Hindawi) has applied three themes to the embedding of Open Science principles and practice in the researcher landscape. Her approach is innovative and perhaps the first to anchor the required cultural change into the process of embracing Open Science principles and practices (MacCallum, 2018).¹⁹

**Open Science =
(Open Outputs + Open Infrastructure) x Cultural Change**



**Access, reuse &
discoverability**



**Evaluation & researcher
behaviour**

There are at least seven challenges in moving to an Open Science environment, from copyright, to costs, to data privacy, and more, but the most difficult one may be cultural change

A first challenge is the prevalence of copyright assignment to commercial publishers and weak copyright literacy amongst researchers. A number of options have been developed to counter wholesale assignment to publishers. The UK Scholarly Communications Licence²⁰, for example, is an attempt to retain copyright for the academic whilst granting the publisher a non-exclusive licence to publish. However, by no means do all publishers currently accept such a bold

18 University of Milan: <http://www.unimi.it/cataloghi/unicom/Scienza%20Aperta%20-%20Relazione%202017.pdf>; last accessed 24 May 2018.

19 For another interesting concept, which considers Open Science as a workflow, see <https://101innovations.wordpress.com/>; last accessed 6 April 2018.

20 UK Scholarly Communications Licence: <http://ukscl.ac.uk/>; last accessed 6 April 2018.

approach to copyright management. The limitations that artistic authorship implies in research processes in art and design should also be borne in mind. In some disciplines, such as artistic ones, it is not easy to fulfil the requirements of Open Access because research activities and results are far from the format of publications; they may comprise complex outputs or formats challenging copyright and openness.

Second, there are costs involved in developing Open Science approaches, particularly in terms of constructing local infrastructure to deliver Open Science solutions. This will require economic changes (Knowledge Exchange, 2017) and such developments have to be funded.

Third, not everything can be open. With patient data, for example, there are good reasons why such information cannot be made generally available. The same is true of information which would endanger national security. Openness is not a panacea which will cure *all* the ills in Society.

Fourth, statements such as the San Francisco Declaration²¹ are by no means universally accepted across academic communities. The use of Journal Impact Factors as a measure for quality is deeply embedded in some research communities. Finding agreement on metrics, and agreeing new models for evaluation, will be a slow task.

Fifth, communities throughout the world are not all equally committed to openness. In a time of transition, therefore, it is inevitable that there will be leaders and followers. Not all countries and continents are equally committed to the open agenda. As such Europe, as a world leader in Open Science, must accept that where it leads, it must be a generous partner so that others will follow.

Sixth, related to this, it is important for Europe that all stakeholders start the journey to embrace Open Science principles, policies and practices. Getting everyone moving together will be a significant task.

Seventh, and perhaps most challenging, is the change of culture required to move to Open Science activity. Open Science, that is Open Scholarship in its fullest sense, requires a change of culture by all those involved in the workflow. Culture does not change overnight and so a parallel programme of change management needs to accompany and support any move to Open Science principles and

practices. There are real dangers in trying to introduce new practices without carrying the academic community with the leaders of those changes. It would be wrong to think that Open Science is simply a blueprint which can be introduced in a mechanistic way into institutions. In many ways, cultural change is the most difficult outcome to achieve in embracing Open Science approaches and this represents a real challenge for universities beset by a host of competing requirements.

LERU formulates four high-level recommendations for universities to embrace Open Science

Scholarship is a complex system. Open Science increases that complexity by explicitly increasing the number of relevant players to include a wider public, new technology and service providers (and their investors), and a broader inclusion of the users of research, alongside traditional players. The transition to Open Science affects all stakeholders in the academic process – universities, researchers, teachers, students, academic support staff, research funders, academic publishers and policy makers. Recognising the challenges of achieving a systems-level change to Open Science, LERU universities agree on four high-level recommendations for how universities can proceed:

1. Appoint a senior manager to lead Open Science approaches across all eight pillars of the Open Science debate identified by the European Commission.
2. Develop a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings.
3. Establish advocacy programmes, which should identify the benefits of Open Science approaches, whilst being realistic about the challenges.
4. Draw up a communication strategy, which enables the whole university body to become familiar with Open Science practices.

21 The Declaration on Research Assessment (DORA) was developed in 2012 during the Annual Meeting of the American Society for Cell Biology in San Francisco.

The eight dimensions of Open Science: A roadmap for universities

1/ The future of scholarly publishing

The changing research landscape and Open Access

"In 1662, the newly formed 'Royal Society of London for Improving Natural Knowledge' was granted a charter to publish by King Charles II, and on 6 March 1665 the first issue of *Philosophical Transactions* appeared under the visionary editorship of Henry Oldenburg, who was also the Secretary of the Society". [...] *Philosophical Transactions* established the important principles of scientific priority and peer review, which have become the central foundations of scientific journals ever since. In 1886, the breadth and scope of scientific discovery had increased to such an extent that it became necessary to divide the journal into two, *Philosophical Transactions A* and *B*, covering the physical sciences and the life sciences respectively".²²

The research landscape has changed a good deal since the foundation of The Royal Society. Widespread access to the World Wide Web from the 1990s has encouraged take-up of the Open Access movement – where outputs are freely available without the requirement to pay subscriptions; and where resulting materials are available for sharing and re-use, ideally supported by the appropriate licence (such as Creative Commons).²³

Not everyone is convinced about Open Access approaches. 'In a statement released on February 28, 2007, the Association of American University Presses (AAUP) outlined its position on the problematic—and often contentious—issue of providing open access to scholarly information, and declared that what was needed at this juncture was careful experimentation and development and not any risky plunging straight into "pure open access."'²⁴ This view is echoed in several academic disciplines in the humanities, which see Open Access as an issue for science, technology and medicine. They also have reservations on some forms of Open Access licensing. In

the Creative Commons suite of licences, for example, some Humanities scholars would only feel comfortable with the most restrictive form of CC licence – CC-BY-NC-ND.

Open Access is not always easy to define in some subject and discipline areas. Exhibitions that constitute, or partly constitute, the publication of art- or design-based research can be considered Open Access if they are presented in public institutions, and announced accordingly. However, they are not accessible for (research) audiences without physical proximity to the presentations/exhibitions. This has to be accounted for as documentation of the event, and this can be made public and openly accessible in wider contexts, and electronically distributed.

This goes also for architectural works that may be presented as artistic works, and as part of artistic research. Such documentation can be reflected in terms of new forms of measurement for impact: the quality does not show in the number of such documented shows, but perhaps in evaluations of those shows, including public critique in journals or mass media, perhaps also in forms of social media.

Open Access initiatives

In 2016, the Amsterdam Call for Action on Open Science called for full Open Access for all scientific (research) publications.²⁵ LERU has made a number of important contributions in this area. In 2011, it published The LERU Roadmap towards Open Access (LERU, 2011) which gave guidance on how to embrace Open Access at an institutional level. In its 'Christmas is over' campaign, LERU issued a statement in 2016 to support the Dutch Presidency of the EU. 'Research funding should go to research, not to publishers!' (LERU, 2016). Almost 10,000 people and organisations signed up to the statement.

A number of European countries have attempted to make

22 Reproduced from Royal Society: <http://rstl.royalsocietypublishing.org/>; last accessed 24 May 2018.

23 Creative Commons: <https://creativecommons.org/licenses/>; last accessed 24 January 2018.

24 Association of American University Presses: <http://blog.historians.org/2007/03/aaup-calls-for-cautious-approach-to-open-access/>; last accessed 15 April 2018.

25 Amsterdam Call for Action: <https://www.government.nl/documents/reports/2016/04/04/amsterdam-call-for-action-on-open-science>; last accessed 2 May 2018.

the transition to Open Access publishing. The Netherlands (Butler, 2016), Finland²⁶, Germany (Schiermeier, 2017) and Switzerland have all been active in this respect. In Germany, Project DEAL “want[s] a deal that would give most scientists in Germany full online access to 2,500 or so Elsevier journals, at about half the price that individual libraries have paid in the past. Open Access is proving to be the sticking point in the talks: under the deal sought, all corresponding authors affiliated with German institutions would be allowed to make their papers free to read and share by anyone in the world at no extra cost”²⁷.

In the UK, the Finch Report (2012) recommended the gold route as the preferred route for Open Access publication. Bodies such as the Wellcome Trust and Research Councils UK give monies to researchers to fund Article Publication Charges (APCs) in both hybrid journals and pure gold journals. The purpose of funding such publishing activity was to transition UK Higher Education to full Open Access. That transition has clearly not worked and the reason is financial. The average cost of an APC paid by a British university is £1700 and, for a productive institution, this average will increase its publishing costs above the current cost of accessing these resources through subscriptions.

New publishing models

It may well be that the current commercial publishing model cannot be adapted to full Open Access publishing. If that is the case, new publishing models need to be identified which will deliver full affordable Open Access. Research monographs are prime candidates for publication as Open Access monographs. The current market in scholarly monograph publishing is collapsing and new providers are appearing (Barclay, 2016). UCL Press, for example, is the UK’s first fully Open Access University Press and is an active Open Access monograph publisher²⁸, with 56 published books (as of November 2017), with 632,281 downloads from 218 countries and 5,866 print-on-demand copies sold. Helsinki University

Press is also in the process of being established as an Open Access publisher.²⁹

Another model for Open Access research monographs is the Freemium model, used by bodies such as OpenEdition, where “OpenEdition Freemium is a programme for the development of open access academic publishing in the humanities and social sciences. This partnership, on offer exclusively to institutions (libraries, campuses, research institutes) aims to create an innovative and sustainable economic model. All income generated by the programme is reinvested in the development of open access academic publishing.”³⁰

Open Access publishing clearly provides a new route of dissemination for the scholarly monograph. Rather than talk of the death of the monograph, we can now envisage a future for this key research output which increases its impact.

Typically, all such approaches to openness include the use of ORCID IDs to help identify authors systematically. ORCID purports to provide “a persistent digital identifier that distinguishes you from every other researcher and, through integration in key research workflows such as manuscript and grant submission, supports automated linkages between you and your professional activities ensuring that your work is recognized.”³¹

There are a number of options for introducing openness into educational outputs. MOOCs (Massive Open Online Courses) and Open Educational Resources (OERs) are common ways to make an entry into the Open Educational landscape. One of the universities with the biggest investment in MOOCs is the University of Edinburgh.³² MOOCs are freely-accessible, open-licensed short courses delivered to large cohorts of students fully online. To date more than 2 million people have signed up to such courses with Edinburgh University. In an Open Access environment, Open Access digital textbooks are a new form of output which can support the Student Experience. UCL Press has launched an Open Access

26 For Finland, see <http://www.nodealnoireview.org/2017/08/29/divide-and-conquer-elsevier-approaches-academic-institutions-and-individual-researchers/>, last accessed 12 February 2018.

27 Project DEAL: <https://www.projekt-deal.de/about-deal/>; last accessed 7 May 2018.

28 UCL Press publishes annual Reports and financial statements; see https://www.ucl.ac.uk/ucl-press/docs/UCL_Press_Annual_Report/; last accessed 15 April 2018.

29 Helsinki University Press: <https://hup.fi/>; last accessed 2 May 2018.

30 OpenEdition: <https://www.openedition.org/14043?lang=en>; last accessed 15 April 2018.

31 ORCID: <https://orcid.org/>; last accessed 15 April 2018.

32 University of Edinburgh: <https://www.ed.ac.uk/studying/moocs>; last accessed 24 May 2018.

textbook project which will produce a dozen textbooks by UCL authors. Such textbooks are fully Open Access stored in the institutional repository³³. The default delivery format is a flat PDF, but an innovative model for textbooks using a new BOOC (Books as Open Online Content) platform is also available.

As part of its work on Open Science, the European Commission has set up the Open Science Policy Platform,³⁴ and a Horizon 2020 expert group on The Future of Scholarly Communication and Scholarly Publishing³⁵. The European Commission has not only introduced requirements in relation to publishing, but also offers support infrastructure, OpenAire,³⁶ and associated services. The Commission also supports the development of this infrastructure through its funded projects under OpenAire+.

A challenging area in which to deliver full Open Access is in the realm of journal publishing. A number of options are available. Where universities have established their own Open Access University Presses, some have started their own Open Access journals. There are other providers of Open Access journals – a well-known provider is the Open Library of Humanities, which currently publishes 20 journals.³⁷ A new approach is also the megajournal model. In essence, a megajournal is a peer reviewed platform presenting scholarly content to a global audience. In scope and concept, it is bigger than the traditional span of a journal.

The advantages of the megajournal approach are many:

- Open peer review, where the reviewers' names and the text of their reviews are fully open
- Post-publication peer review is possible
- Fast turn-around between receiving a manuscript and publishing it
- Megajournals facilitate inter-disciplinary and cross-disciplinary work since they have a broad subject scope which covers a multiplicity of traditional disciplines

However, there are also perceived disadvantages in the megajournal approach. Some would argue that there are

already sufficient megajournals (e.g. funder platforms such as the Wellcome's Open Research platform³⁸ and the new platform being funded by the European Commission [European Commission, 2017b]) and that the market is saturated. Another problem with a megajournal is it decreases the discoverability of work – a journal name helps pinpoint an article within a discipline.

One way to tackle the challenge of numbers would be via collaboration. Universities could collaborate in producing megajournals. LERU could develop a megajournal platform where member universities could collaborate together over journal production. Another model for journal production is to retain the traditional notion of a journal 'title', but to make the outputs open. This is a model which has been adopted by some universities. The University of Milan has implemented an OJS platform that publishes 30 journals with 600,000 downloads per year. The journals are indexed in Scopus and the Emerging Sources Citation Index from the Web of Science. Clearly, there are a growing number of ways in which universities can take back publishing into the academic community and themselves take on the role of publisher, using new publishing paradigms.

The role of research funders in supporting and fostering the transition to Open Access and new publishing models is key. The Horizon 2020 Research and Innovation programme has strict rules about the need for funded research outputs to be Open Access. The Model Grant Agreement sets out detailed legal requirements on Open Access to scientific publications: under Horizon 2020, each beneficiary must ensure Open Access to all peer-reviewed scientific publications relating to its results (European Commission, 2017a). Similar arrangements are expected for its successor, the Horizon Europe programme. Horizon Europe will be regarded as an intervention to help the transition towards Open Science and we expect the current rules of Horizon 2020 in relation to Open Access and research data to continue in Horizon Europe, and that in general Open Science will become even more important.

33 See UCL Discovery webpage: <http://discovery.ucl.ac.uk/>; last accessed 22 May 2018.

34 European Commission's Open Science Policy Platform: <https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform>; last accessed 12 February 2018.

35 Horizon 2020 expert group on The Future of Scholarly Communication and Scholarly Publishing: <http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupId=3463>; last accessed 7 May 2018.

36 OpenAire: <https://www.openaire.eu/>; last accessed 15 April 2018.

37 Open Library of Humanities: <https://www.openlibhums.org/journals/>; last accessed 24 January 2018.

38 Wellcome Open Research: <https://wellcomeopenresearch.org/>; last accessed 15 April 2018.

Recommendations on the future of scholarly publishing

LERU recommends that universities:

1. Have institutional mandates to support the move to full Open Access, whose implementation can be monitored regularly.
2. Deliver a roadmap for how they, or specific groupings, can develop agreed plans for the future of scholarly publishing in their institution.
3. Advocate the use of author identifier systems such as ORCID across their institution.
4. Consider supporting new forms of scholarly publishing from third parties dedicated to Open Access approaches.
5. Where appropriate, establish new mechanisms for scholarly publishing based on the good practice identified in this paper.

2/ FAIR data

Research data sharing

For the last fifteen years, research performing institutions have been focused in trying to share their publications as openly as possible. However, now the focus has shifted to research data because publications are already being shared in institutional repositories and open access journals, and research data is seen as the needed element to validate and reproduce research outcomes. Nowadays, in the current data-intensive landscape, it is not enough to disseminate research results as publications. Sharing research data is part of a general move to give such research outputs at least the same visibility as publications. The EU-funded LEARN³⁹ project created a number of outputs to support responsible research data management (RDM): case studies of best practices, a model research data management policy, Key Performance Indicators, and an RDM Readiness survey.

There are challenges to establishing responsible RDM practices. Some researchers feel challenged by the need for research data management plans and the requirements of

the General Data Protection Regulation (GDPR).⁴⁰ To improve research data management, research funding and research performing organisations increasingly require researchers to develop a Data Management Plan (DMP) for their project proposals or their evaluation. Science Europe has developed a Framework for Domain Data Protocols. The Framework's set of minimum requirements (or terms of reference) encompasses matters such as the implementation of applicable laws and regulations, references to standard data formats and software principles. It also deals with references to FAIR data and elements that allow for funding agencies and governments to be properly accountable for the funds spent on research. This Framework should be considered as the basis for the development of Domain Data Protocols by the various scientific communities (Science Europe, 2018).

Peers and citizens are demanding from researchers access to their texts and to all the elements underpinning their findings. The findings of the public consultation on Science 2.0 showed that researchers were interested in data sharing, stating that:

A final policy intervention discussed by several stakeholders was support for data sharing, management, curation and storage. Specific interventions would include building relevant infrastructure, developing data skills, incentivising data sharing, and nurturing the development of good practice in handling data.⁴¹

To share data is not new because some scientific disciplines have been doing so for many years, whilst other researchers may have published such outputs sporadically along with their publications. However, now there are many infrastructures providing storage for and access to research data. Policies from funders and publishers, requiring a broader dissemination of research data, are being produced. Research performing institutions must be prepared to fulfil these expectations and to provide suitable tools and services for their researchers.

39 LEARN: <http://learn-rdm.eu>; last accessed 17 April 2018. The EU-funded LEARN project took the LERU Roadmap for Research Data and developed a model research data management policy for research institutions, a set of 20 recommendations on how to embed research data management into research activity, a series of best practice case studies, an executive briefing in 6 languages for senior institutional managers, a series of key performance indicators which would measure success in embedding research data management in an institution or research group, and a self-assessment tool to help identify areas of weakness.

40 For more information about the GDPR see: https://ec.europa.eu/info/law/law-topic/data-protection_en; last accessed 23 May 2018.

41 Science 2.0 consultation: <https://ec.europa.eu/digital-single-market/en/news/final-report-science-20-public-consultation>, section 3.2; last accessed 17 April 2018. Regarding evidence from citizens, see Schade, S. et al. (2017).

The FAIR DATA principles

Sharing data is not just a question of publishing some figures or files. Data must be shared in a way that machines and humans can understand them and re-use them. For that purpose, a few years ago a group of researchers published the FAIR Data Principles which describe how research data should be shared (Wilkinson, 2016).⁴² FAIR stands for Findable, Accessible, Interoperable and Reusable and these are the features that research data should possess when shared.

Research performing institutions must therefore foster the adoption of these FAIR principles among their researchers when sharing data and extend them to any other research output. This is an activity best undertaken in partnership with others, where appropriate. Therefore, research funders can take a relevant role in the adoption of FAIR principles by including them by default as a mandatory research requirement in any funded research activity. There are challenges in adopting such a position, not least the disciplinary differences that exist between subject areas. We should be sensitive to such disciplinary differences in research practice, particularly whilst we are in a transition period to full Open Science practices. A historian, for example, may be building a single dataset over their academic lifetime which is never 'finished' and which defines their scholarly persona. It is very different for a scientist who produces a dataset as part of a project and then moves on to a new project. The requirement for FAIR data brings with it a need for universities, research funders and other stakeholders to understand what FAIR means in each subject area.

Recommendations on FAIR data

LERU recommends that universities:

1. Adopt or update an institutional policy on research data management –ideally modelled on the template produced by LEARN⁴³– embracing the FAIR principles and based on an 'as open as possible, as closed as necessary' philosophy, and that they establish a dedicated committee on research data management to monitor the

implementation and uptake of such a policy.

2. Design and establish services for data stewardship, provide researchers with suitable infrastructures, and identify funding and resources to archive and to publish data.
3. Create a catalogue of where researchers have published data (or stored if not available for any reason) as is currently done with publications, and consider how to use this information in any research assessment or evaluation (cf. recommendations on rewards).
4. Provide free access to metadata in order to facilitate the discovery of data for which access must be restricted because of privacy, security, or confidentiality issues, making sure such metadata fulfill the FAIR principles, and establish a grade of accessibility to those restricted research data.⁴⁴
5. Establish training sessions on research data management at all levels, starting from students (cf. recommendations on education and skills).
6. Work together with any local, national or international activities, using for instance Research Data Alliance national groups⁴⁵ or the Digital Curation Centre's Data Management Tool.⁴⁶

3/ The European Open Science Cloud (EOSC)

The European Open Science Cloud

The European Open Science Cloud is a major component of the European Commission's concept of Open Science. The Report which supported the development of the Cloud, 'Realising the European Open Science Cloud', identified a strong vision for this key piece of Open Science infrastructure, stating that:

The European Open Science Cloud (EOSC) aims to accelerate and support the current transition to more effective Open Science and Open Innovation in the Digital Single Market. It should enable trusted access to services, systems and the re-use of shared scientific data across disciplinary, social and geographical borders (Mons, 2016: 6).⁴⁷

42 See also The FAIR Data Principles: <https://www.force11.org/group/fairgroup/fairprinciples>; last accessed 17 April 2018.

43 LEARN Research Data Management toolkit: <http://learn-rdm.eu/en/research-data-management-toolkit-now-available/>; last accessed 7 May 2018.

44 An example of degrees of access for sensitive research data is available at <http://datatags.org>; last accessed 17 April 2018.

45 Research Data Alliance: <https://www.rd-alliance.org/groups/national-groups>; last accessed 17 April 2018.

46 The Digital Curation Centre's Data Management tool: <http://www.dcc.ac.uk/resources/data-management-plans>; last accessed 8 May 2018.

47 'The EOSC is indeed a European infrastructure, but it should be globally interoperable and accessible. It includes the required human expertise, resources, standards, best practices as well as the underpinning technical infrastructures. An important aspect of the EOSC is systematic and professional data management and long-term stewardship of scientific data assets and services in Europe and globally. However, data stewardship is not a goal in itself and the final realm of the EOSC is the frontier of science and innovation in Europe' (Mons, B. et al., 2016: 6)

There are two big challenges here for universities. First, the technical standards and protocols for accessing the EOSC remain to be confirmed. The European Commission's vision is for these arrangements and protocols to be as easy as possible to embrace, taking inspiration for this from the way the Internet has grown around use of the http: protocol. That being said, arrangements are still unclear but light is being shed on them by the EOSC pilot, which has as its mission:⁴⁸

- Facilitating access of researchers across all scientific disciplines to data
- Establishing a governance and business model that sets the rules for the use of EOSC
- Creating a cross-border and multi-disciplinary open innovation environment for research data, knowledge and services
- Establishing global standards for interoperability for scientific data

A second point that universities should note is that the EOSC will not build a central infrastructure or data archive or repository. Rather, it will link interoperable infrastructures where they exist. Countries, research organisations and universities must thus invest in such infrastructures in order to engage with the EOSC as a pan-European development. Cost is an important factor in such developments. How much will institutions have to pay in order to have the necessary infrastructure in place to interact with the EOSC? This is a key question for all universities and one that is extremely difficult to answer, since universities either do not have all the necessary infrastructure in place or else do not disclose their costs. The Horizon 2020-funded LEARN project, led by UCL with Barcelona as a member, found this question extremely challenging to answer. In a survey of European universities, they were able to identify costs for research data storage at the University of Edinburgh.⁴⁹

The European Commission is investing extensively in the EOSC, but the services that are being developed are sometimes far removed from the day to day realities of all European researchers. The EOSC needs to embrace a more inclusive and practitioner-oriented approach to engage researchers, support staff and service providers at universities in the development of its services. The EOSC should develop a more customer-centric approach to stakeholder outreach, which would facilitate engagement with

researchers, academic support staff and service providers at universities in the development of its services.

It is sometimes a challenge for universities to engage with such externally-developed products and services. With limited capacity, this is often not a straight forward task. A more inclusive approach to the development of infrastructure projects financed by the European Commission would invite universities to share knowledge and experience. Such collaboration in the early stages of new developments would facilitate better alignment of the required support structures within universities to the EOSC requirements.

The EOSC represents a major shift in the culture of how to share the outcomes and outputs of research and educational activity and has the potential to put Europe in a position of leadership in the global research environment.

EOSC Declaration

LERU is a signatory to the 'EOSC Declaration',⁵⁰ which propounds 33 goals for European organisations engaged in research data management under the following headings:

- Data culture and FAIR data (15)
- Research data services and architecture (11)
- Governance and Funding (7)

Fundamental to realising the concept of EOSC is the requirement that all research data produced by European researchers is, where possible, FAIR – Findable, Accessible, Interoperable and Reusable. This is treated in more detail in the chapter on FAIR research data. The EOSC Declaration builds in part on work which LERU has already undertaken in the field of research data management. The 'LERU Roadmap for Research Data' made 44 recommendations aimed at different stakeholders in the research data landscape (LERU, 2013: 31-33) .

Go FAIR

The Go FAIR⁵¹ initiative follows a bottom-up open implementation strategy for the technical governance and funding needed to establish the first phase of the EOSC as part of a broader global Internet of FAIR data and services. The activities of the GO FAIR initiative focus on FAIR data and services, technology, training and certification.

48 EOSC Pilot: <https://eoscpiot.eu>; last accessed 15 April 2018.

49 LEARN: <http://learn-rdm.eu/toolkit>, case study 17; last accessed 15 April 2018.

50 EOSC Declaration: <https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud>; last accessed 28 January 2018.

51 Go FAIR: <https://www.go-fair.org/>; last accessed 17 April 2018.

Recommendations on EOSC

LERU recommends that universities:

1. Ensure institutional access to the requisite infrastructure, such as a locally-managed data repository where research data is available for sharing and reuse, or that they ensure researchers understand where third-party storage solutions are available, which can themselves be part of the EOSC.
2. Provide a search and discovery service, enabling users to find what research data is available and where it is located, as it is key to the wider use of such resources and, therefore, of the vision embodied in the EOSC.
3. Move to sign the EOSC Declaration over time, as a statement of commitment at a local level, as LERU has done as an international network.
4. Develop their research data management offering so that it is aligned with the principles of engagement with the EOSC, once the latter are agreed and available, and in the expectation that the EOSC develops a more customer-centric approach to stakeholder outreach, which would facilitate engagement with researchers, academic support staff and service providers at universities in the development of its services.

4/ Education and skills

In order to infuse an Open Science culture throughout the university, the organisation and all the people in it – students, researchers, teachers, support staff, management and leadership – need to understand the benefits of Open Science along its various dimensions. Raising awareness about Open Science and its potential benefits and providing skills training in Open Science practices are crucial to achieve the culture shift which is needed to open up universities to an Open Science culture.

Open Science comprises several dimensions. Clearly, there is an evident need for skills training with regard to scholarly publishing and research data management; those are the areas of Open Science in which universities tend to invest most at the moment. Also research integrity and ethics courses, and increasingly, citizen science courses, are important. A survey of doctoral programmes at LERU universities revealed that one of the most common (out of few) *mandatory* skills training courses for doctoral students

were research integrity courses. LERU itself has dedicated doctoral summer schools to the topics of Open Science, data stewardship and research integrity.

Open Science skills training is beneficial to a variety of audiences at universities, such as researchers at all career phases (from doctoral researchers to senior professors (R1-R4), and students at the bachelor and masters' levels.⁵² Also teachers, research management staff, data scientists, data stewards, copyright officers, librarians and citizen scientists may benefit from Open Science training, which needs to be tailored to the needs of specific subgroups. Finally, supporting role models and training the trainers may need to be considered.

How training is delivered should be considered carefully, as it will vary according to needs, audiences and resources. Skills may develop in different learning contexts, including in-person or distance, classroom, webinars, blended or not. Universities develop and deliver (some of) their own training and often also work with external providers. Examples of many kinds of innovative training are available for universities to use or to get inspired. While formal training is almost always needed, researchers can and do also acquire Open Science skills in informal training circumstances, on-the-job and at-the-research-bench.

Elements of Open Science skills training should be required. Universities can use a variety of mechanisms to record and acknowledge the training (e.g. credits, certificates of attendance, etc.), so that one can demonstrate Open Science competencies as part of career development, appraisals or promotions. For example, it is quite common at LERU universities to log skills development by doctoral researchers (LERU, 2016a, 2016e) in online progress tools or similar study management and supervisory systems. Open Science skills training should be firmly embedded in this and should be acknowledged in professional development and career progression of all university staff.

Given that comprehensive universities are complex organizations with many faculties, units and services and that they operate in a rich variety of national (and other) contexts, the provision of skills training is generally also rich, varied and distributed. It is useful for universities to map or revisit their (needs for provision of) skills development with a view to develop an agreed, strategic approach to Open

52 Elements of Open Science should also be given a place in pre-tertiary education, even with young school children. However, this discussion is beyond the scope of this paper.

Science skills training, the overall aim of which is to bring about Open Science cultural change. Mutual learning and exchange of good practice between universities at several levels (regional, national, European) are instrumental in working towards bringing about comparability and portability of Open Science skills training for mobile students and staff. LERU believes that to prescribe a uniform or standardized approach to Open Science training at universities would be ineffective and could even be counter-productive.

In developing this approach, universities will need to take into account the actions and policies of other research stakeholders, including funders, publishers, governments, professional societies. Broad dialogue and concerted efforts across the research community will be needed, as has been suggested in the Open Science skills working group report prepared for the Open Science Policy Platform (O'Carroll, 2017b).

Recommendations on education and skills

LERU recommends that universities:

1. Integrate Open Science concepts, thinking, and its practical applications in educational and skills development programmes, analysing and mapping their needs for Open Science skills training, taking into account the different Open Science dimensions and the varying needs of different audiences, different disciplines, etc.
2. Encourage, incentivise, support and recognise staff and students with regard to Open Science skills development.
3. Determine how to resource Open Science skills training in a sustainable manner.
4. Monitor the take-up and impact of Open Science skills training to determine progress towards its cultural integration in the institution.
5. Explore innovative mechanisms and tools to provide Open Science skills training, and engage with others outside the university to exchange good practice.

5/ Rewards and incentives

LERU is not only a strong supporter of Open Science, it has also been actively engaged on the topic of researchers' careers (LERU, 2010, 2014, 2018a, 2018b). Moreover, researchers' careers have also been a European Commission priority, from the inclusion in the European Research Area (ERA) priorities to initiatives such as the European Charter for Researchers and Code of Conduct, the Human Resources Strategy for Researchers (HRS4R), the Euraxess portal and the pension scheme Resaver.

Many researchers increasingly or (more or less) routinely adopt Open Science approaches, thus ensuring that the benefits which openness brings, such as the accessibility, reproducibility and transparency of research, are available to students, colleagues, and to society as a whole. It is only fair that such efforts should not only be incentivised and valued, but also and professionally recognised and rewarded. In reality however, appointment, promotion and advancement processes (and also funding processes) still have to catch up to Open Science. They still tend to rely heavily on traditional and often quantitative measurements to evaluate researchers' performance, some of which are not fit-for-purpose, e.g. journal impact factors. To be sure, both quantitative (metrics-informed) and qualitative (involving expert judgement) approaches to assessment are appropriate in science (open or closed). LERU views the role of the former to support, not to replace, the latter (LERU, 2012).

With the rapid growth of Open Science, a whole range of alternative or new metrics are developing, not only in response to Open Science, but also as a result of other drivers, such as the societal impact agenda with its focus on public engagement (cf. citizen science). It is important to realise that alternative or next-generation metrics (e.g. Altmetric, Plumx, ImpactStory) are in theory susceptible to the same pitfalls as traditional metrics, i.e. they need to be scientifically grounded and handled sensibly, they can be "gamed", "over-commercialised", etc.

The transition to Open Science coincides with a movement away from exclusively or primarily quantitative and metrics-focused assessment to a better and sensible mix of quantitative and qualitative assessment. To be successful, it should also be aligned with a transition to assessing researchers' performance on a broader, multi-dimensional basis, which includes not only research and their Open Science activities but also a broader set of other professional achievements, ranging from educational engagement, to teamwork and collaboration, supervision of junior colleagues, institutional citizenship, service to the profession or to society at large, etc.

Arguably, this part of the transition to Open Science is one of the biggest challenges and requires a profound shift in the minds and hearts of people and institutions, not only universities but also governments and funders. As was stated in a recent report by the European Research Area Committee (ERAC, 2018), incentives and rewards are a sensitive policy issue, closely linked to research careers and promotion, and there are significant national, regional and institutional differences, although there is broad consensus

on the necessity of reform. An EU-level policy approach on assessment, evaluation and reward systems thus has to happen in close coordination with the member states (and associated countries).

Recommendations on rewards and incentives

LERU recommends that universities:

1. Endeavour to integrate Open Science dimensions in their HR and career frameworks as an explicit element in recruitment, performance evaluation and career advancement policies, so that research and teaching staff are appropriately recognised and rewarded for practicing Open Science.
2. Develop institutional policies for recognising and rewarding Open Science practice anchored in broad-based support; communicate them clearly and transparently, make them easy to find and access, and provide proper guidance or training to those who are involved in staff recruitment, appraisal and promotion in the university.
3. Develop individual HR criteria for recognising and rewarding Open Science in job descriptions, performance appraisals and promotion criteria, for all or most research and teaching staff, which take into account their multiple responsibilities, in terms of research output, process, impact, teaching and supervision, leadership, service to the university, public engagement, professional experience, as well as considering collaborative and team accomplishments in addition to individual accomplishments when appropriate.
4. Embed Open Science principles in the institutional research assessment system⁵³, shifting away from an excessive reliance on publication-based journal impact factors and citation cultures and recognising Open Science approaches such as OA publishing, data/code/reagent sharing, recognising pre-prints, etc.
5. Offer appropriate support, professional development and training opportunities for Open Science, aligned with employees' different needs depending on discipline, career progression, seniority and goals, including moving outside the university (cf. recommendations on education and skills).
6. Periodically monitor, reflect on and update their Open Science rewards system so it remains fresh and fit-for-purpose.

6/ Next-generation metrics

Next-generation metrics and bibliometrics

Next-generation metrics is the name used in this paper to describe the activity which some stakeholders misleadingly refer to as Altmetrics. It is one of the eight pillars of the European Commission's definition of Open Science, although the name does not do justice to the importance of the topic. It would be much more accurate to say that the issue refers to (a) the responsible use of existing bibliometrics and (b) the use of new bibliometric measures which are aligned with the ambitions of Open Science. For this reason, the phrase next-generation metrics is used in this paper.

Traditionally, bibliometrics is the use of statistical analysis to evaluate the importance and impact of publications on the wider community. In an Open Science environment, the challenge is to extend the range of bibliometrics to cover new forms of output, such as research data and research software, with new metric measures; and also to agree principles for the responsible use of metrics. The change in culture needed to achieve these objectives is one of the biggest challenges facing those who embed Open Science practices into the academic environment.

Journal Impact Factors

One of the most common bibliometric measures used by researchers, journals and universities is the Journal Impact Factor (JIF). The JIF is a measure reflecting the yearly average number of citations to recent articles published in that journal. It is often used as a surrogate for the quality of individual articles in a journal. This is a mistaken use of this particular measure. JIFs say nothing about the academic quality of individual articles in journal runs. As such, the JIF cannot and should not be used as a surrogate for the quality of individual articles. As the UK REF (Research Excellence Framework) has stated, neither journal impact factors, nor the journal title in which research outputs are published, should be used as proxies for the assessment of the quality of research outputs (Hill, 2013). That being said, very many individuals and committees in European universities do use the JIF as a surrogate for quality. It is a practice which is deeply embedded and a great challenge to change.

53 The Open Science Career Assessment Matrix (OS-CAM), proposed by the EU Working Group on Open Science Rewards (O'Carroll, 2017: 15-17), may provide a useful starting point to develop an institutional system.

DORA (San Francisco Declaration on Research Assessment), the Leiden Manifesto and the Metric Tide

A major move towards new ways of evaluation is the San Francisco Declaration on Research Assessment (DORA). The Declaration makes 18 recommendations, including 2 aimed directly at universities⁵⁴. LERU is a signatory to DORA, but whilst DORA itself identifies principles for future activity, there is no accompanying roadmap or activity to 'operationalise' the DORA principles into good practice. This has been a major weakness in moving to change the assessment culture in the academic community.

The Leiden Manifesto for research metrics⁵⁵ proposes 10 principles for the responsible use of metrics. The best decisions are taken by combining robust statistics with sensitivity to the aim and nature of the research that is evaluated. Both quantitative and qualitative evidence are needed.

A third influential report on the responsible use of metrics is 'The Metric Tide', produced by James Wilsdon (2015), Professor of Research Policy and Faculty Director of Research & Innovation, Faculty of Social Sciences, University of Sheffield (UK). The review identified 20 recommendations for further work and action by stakeholders across the UK research system⁵⁶.

Open Science Policy Platform: Next-generation metrics

A European Commission Open Science Policy Platform expert group has produced a report on next-generation metrics (Wilsdon, 2017). Given the hesitations in using the name Altmetrics outlined above, the European Commission should dispel confusion by choosing a new name to describe its work in this area and to standardise on its use.

The report identifies five headline findings, supported by 12 targeted recommendations (Wilsdon, 2017: 15-17). The findings are:

1. An Open Science system should be grounded in a mix of expert judgement, quantitative and qualitative measures;

2. Transparency and accuracy are crucial;
3. Make better use of existing metrics for Open Science;
4. Next-generation metrics should be underpinned by an open, transparent and linked data infrastructure;
5. Measure what matters.

Next-generation metrics are a difficult concept to take forward. It is easy to say that quality cannot be reduced to a mere numerical value. It is much less easy for the academic community to agree what could take their place. There has been a sharp growth in recent years in various commercial services. These often use similar source data (e.g. number of tweets or download figures) but interpreted and presented in different ways. Depending on what indicators are used, they can show scholarly interest (e.g. Mendeley bookmarking), media interest (e.g. news stories), or public interest (e.g. social media activity). They can also be used to identify the use of research in policy documents or other official publications which may not appear in the conventional citation databases. Spikes in activity may come if a piece of work is particularly contentious, timely, or simply on a topic that catches the public imagination. It is harder to gather standardised and comprehensive data in this environment than citation data.

In general, it is best to treat next-generation metric figures as broad indicators – high activity tells us that there is something interesting there, but the details should be examined before drawing conclusions. They should not be used to quote a single numeric 'score' for ranking a paper or author.

Recommendations on next-generation metrics

LERU recommends that universities:

1. Develop a bibliometrics policy grounded in the principles of the Leiden Manifesto, with the aim of changing the culture in the academic community about research assessment.
2. Embed the new forms of research evaluation in its internal processes for promotion/reward and research evaluation.

54 DORA: <https://sf-dora.org/>; last accessed 24 May 2018. In relation to academic appointments, it says: '4. Be explicit about the criteria used to reach hiring, tenure, and promotion decisions, clearly highlighting, especially for early-stage investigators, that the scientific content of a paper is much more important than publication metrics or the identity of the journal in which it was published.'

55 The Leiden Manifesto for Research Metrics: <http://www.leidenmanifesto.org/>; last accessed 24 May 2018.

56 Many of the findings are applicable across the globe, including:

- There is considerable scepticism among researchers, universities, representative bodies and learned societies about the broader use of metrics in research assessment and management.
- Carefully selected indicators can complement decision-making, but a 'variable geometry' of expert judgement, quantitative indicators and qualitative measures that respect research diversity will be required.

3. Construct, via appropriate internal bodies, guidance for research administrators and academics on good and bad practice in the use of traditional bibliometrics and in the development of new metrics, and that they work with the scientific community in this endeavour.
4. Provide training to junior researchers, particularly early-stage doctoral researchers, enabling them to embrace the change of culture and practice which the responsible use of metrics brings (cf. recommendations on education and skills).

7/ Research integrity

Research integrity is one of the cornerstones on which science is built. There can be no excellent science if research practices are not based on reliability, honesty, respect and accountability, principles identified as fundamental by the European Code of Conduct for Research Integrity⁵⁷. Research integrity is the basis of trust (Science Europe, 2015)⁵⁸, and Open Science –as a new approach to scientific process- should maintain research integrity at its core.

Open Science practices, such as open access publishing, open data, open peer review and open research, have the potential to bring about new and exciting pathways for supporting a culture of research integrity. By diffusing knowledge at an earlier stage in the research process and opening up access to research data and research results, Open Science increases transparency and encourages dissemination. Wider dissemination and increased openness help to demonstrate the responsible conduct of research, enable errors or omissions to be addressed and facilitate verification and reproduction of findings. Reproducible research⁵⁹ is imperative and Open Science fosters it. Open Science practices may also discourage and reduce the incidences of fabrication, falsification, plagiarism and other unacceptable practices by making them easier to detect, but do require legal and ethical awareness on the part of researchers. Open Science can also strengthen the leading role that Europe should develop in research integrity at the global level. Universities are ready to rise to the challenge and play a key role in achieving this.

Next to the opportunities, Open Science practices also bring about new challenges to the responsible conduct of research. As indicated by the EU Research, Innovation and Science Policy Experts, without research integrity, “data are at best worthless” and “at worst, poor data are positively dangerous” (Ritter, 2017: 87). The relationship between open data and ethical and privacy standards becomes increasingly complex and relevant in a context of data-intensive research.

Recommendations on research integrity

LERU recommends that universities:

1. Promote and develop awareness amongst the research community of how Open Science can ensure the highest standards of research.
2. Have a research integrity code which embraces the principles of Open Science or that they abide by the European Code for Research Integrity (ALLEA Code), in which, next to general principles of reliability, honesty, respect and accountability, good research practice includes inter alia:
 - a. Research institutions rewarding open and reproducible practices in hiring and promotion of researchers (cf. recommendations on recognition and rewards);
 - b. Authors ensuring that their work is made available to colleagues in a timely, open, transparent, and accurate manner, unless otherwise agreed;
 - c. Making research data as open as possible, as closed as necessary, in line with the FAIR principles for research data management;
 - d. Partners in research collaborations agreeing at the outset on the goals of the research and on the process for communicating their research as transparently and openly as possible;
 - e. Researchers adhering to the same criteria whether they publish in a subscription journal, an open access journal or in any other alternative publication form.

8/ Citizen science

The past decades have witnessed an upsurge in “citizen science”, the active involvement of non-professional

57 The European Code for Research Integrity:

<http://www.allea.org/wp-content/uploads/2017/03/ALLEA-European-Code-of-Conduct-for-Research-Integrity-2017-1.pdf>; last accessed 24 May 2018.

58 “Therefore, research integrity is at the core of science and scholarship. It is the basis for researchers to trust in each other as well as in the research record. Equally importantly, it is the basis of society's trust in the research system.” (Science Europe, 2015: 3)

59 New York University Libraries started a service to support researchers with the reproducibility of their research:

https://guides.nyu.edu/data_management/reproducibility

scientists in research. From grassroots community initiatives to university-based projects managed by professional scientists, citizens' involvement in science takes many forms and has brought about a wide range of activities. In a paper published in 2016⁶⁰, LERU analysed trends in citizen science, formulated actionable guidelines for scientists and gave recommendations for universities, policymakers and funders.

Citizen science results from and contributes to Open Science. It is enabled by the rise of new technologies (such as the internet, the web or mobile phones), open source software and hardware tools or online social network platforms. At the same time, citizen science actively contributes to furthering Open Science by "opening up" the scope of academic research and the actors involved in the research process.

Citizen science allows research projects to use large and varied data sets collected by citizens, to tap the experience and knowledge of citizens; it enhances universities' engagement with society and fosters citizens' scientific involvement. Both universities and society at large can benefit from citizen science. However, for citizen science to be "science" it needs to adhere to scientific standards. Citizen's involvement in science has to abide by fundamental research principles, methods and procedures so as to ensure accuracy and validity and be truly beneficial to research.

Although acknowledging the vast array of activities falling within the concept of "citizen science", the focus is here on research and universities, providing recommendations to support professional researchers who engage with citizen science.

Researchers developing citizen science projects should invest in outreach and community management to ensure adequate numbers and diversity in the project, they should clearly define the impact they aim to have and encourage all participants fully to contribute their talents and creativity to the project. Citizen participants should be recognized properly and provided with clear terms and conditions of participation and the adoption of codes of conduct should be encouraged. Researchers should also adopt Open Science standards consistent with their institutional policies (open access publication, open data standards, open source software, and extending to full transparency of research methods). A long-term data preservation plan that enables open access to results and data, ideally sustainable beyond the end of the project should be adopted.

To support these efforts, research funding organisations are encouraged to promote the use of Open Science practices in citizen science projects (by requiring open access to publications, open data standards, use of open source software, ...), to recognise a wide range of success criteria when supporting citizen science projects and to ensure adequate funding for community management, platform development and other non-research functions characteristic of citizen science.

Policy making bodies are encouraged to develop guidelines for legal, ethical, commercial and privacy issues, to encourage long-term collaboration between research universities and non-governmental organisations and to commission independent studies to evaluate the reliability of citizen science and help ensure projects use evidence-based methodologies.

Recommendations on citizen science

LERU recommends that universities:

1. Recognise citizen science as an evolving set of research methods, as well as its societal and educational benefits.
2. Consider creating, where viable, a single point of contact for citizen science within the institution.
3. Raise awareness amongst researchers of criteria for successful citizen science and ensure compliance with ethical, legal and privacy regulations.
4. Develop ways of assessing citizen science contributions and adapt research evaluation and reputation systems accordingly.
5. Ensure that proposals to granting bodies for citizen science projects include long-term commitment for infrastructures and data repositories.

60 This chapter is built upon the LERU paper (LERU, 2016c).

Conclusions

In the 16th century, the invention of moveable type printing in the West revolutionised the way ideas were transmitted and received. The Protestants in particular seized on the printing press to disseminate their ideas in the vernacular tongue of the country where they were based. The result was to change forever the way society behaved and what it believed. So too in the 21st century, Open Science has the power to change how universities produce, store and disseminate their research and educational outputs. This increased openness also has the power to change the way universities interact with society.

The LERU universities agree that overall there are great benefits to be derived from embracing Open Science approaches. Perhaps one of our most important messages in this paper is to emphasise the need for cultural change at the university level. We suggest universities should develop a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings. Universities can establish advocacy programmes, which should identify the benefits of Open Science approaches, whilst being realistic about the challenges. They may wish to draw up a communication strategy, which enables the whole university body to become familiar with Open Science practices, and they may want to appoint a senior manager to lead Open Science approaches across all eight pillars of Open Science.

We are convinced Open Science brings new and exciting opportunities for the scholarly community and for how academics interact with society. For example, in the area of scholarly publishing we see the impact of Open Access research monographs with high download figures when currently sales of traditional, commercially-produced academic monographs are under significant pressure. In the area of research data and FAIR data, the adoption of the principle 'As open as possible, as closed as necessary' means that the building blocks on which publications are based can be made available for the scholarly community to replicate and verify research findings. This transparency is good for the university, good for the researcher and hence good for the role of the university in society.

Although the potential benefits outlined in our paper are substantial, the challenges for universities on the road to Open Science are not to be underestimated. For one,

costs are always an issue and can be hard to determine, as is the case in the area of research data management, where the true costs of establishing credible infrastructures and for interfacing with the emerging European Open Science Cloud are a particular difficult challenge. Another important challenge is academic reluctance to change well-honed practices. For next-generation metrics, it is clear that traditional forms of evaluation may not easily work in an open landscape. Nevertheless, the community is still far from clear about what can replace them. Options exist, but these have not yet received universal acceptance. The Journal Impact Factor is still alive in many institutions despite the publication of the San Francisco Declaration on Research Assessment (DORA).

Our paper illustrates a model by which universities can embrace change and embed new policies, practices and principles at university level and points out innovative practice as it emerges at LERU universities and in other organisations. To engage with Open Science, universities can work with the 41 recommendations we make for all its eight areas (grouped together in appendix 1). We also offer a set of 37 questions (in appendix 2) which universities can use to monitor progress in adopting Open Science principles, practices and policies at a local level. Each of the questions is drawn from the recommendations in the present paper and, taken together, the answers to the questions will provide a compelling narrative locally regarding progress in the Open Science agenda. The questions can be used iteratively to monitor performance periodically (preferably annually), so that progress can be identified and remaining priorities established.

Open Science represents a fundamental change in the way universities and their scholars work. It brings many benefits, but also many challenges. Universities that are able to capitalise on the opportunities that Open Science brings stand to gain a lot in terms of competitive advantages and added value for the organisation, the people in it and society at large.

References

- Barclay, D. A. (2016). "The End of the Printed Scholarly Monograph: Collapsing Markets and New Models", *Journal International Higher Education*, 0(85), 1 April. <https://escholarship.org/uc/item/7s19j53z>; last accessed 22 May 2018.
- Butler, D. (2016). "Dutch lead European push to flip journals to open access. Academic consortia urge faster changes in scholarly publishing", *Nature*, 6 January. <https://www.nature.com/news/dutch-lead-european-push-to-flip-journals-to-open-access-1.19111>; last accessed 22 May 2018.
- Council of the European Union (2016). "The transition towards an Open Science system", 27 May. <http://data.consilium.europa.eu/doc/document/ST-9526-2016-INIT/en/pdf>; last accessed 23 April 2018.
- Hill, S. (2013). "The end of journal impact factors?", blog post, 20 May. <http://stevenhill.org.uk/the-end-of-journal-impact-factors/>; last accessed 23 May 2018.
- Ehlers, U., Schneckenberg, D. (eds) (2010). *Changing Cultures in Higher Education: Moving Ahead to Future Learning* (Berlin: Springer).
- European Commission (2016). *Open Innovation, Open Science, Open to the World. A vision for Europe*. May. <https://doi.org/10.2777/061652>; last accessed 28 May 2018.
- European Commission (2017a). "H2020 Programme Guidelines to the Rules on Open Access to Scientific Publications and Open Access to Research Data in Horizon 2020", 21 March. <http://ec.europa.eu/research/openscience/index.cfm?pg=openaccess>; last accessed 10 May 2018.
- European Commission (2017b). "Towards a Horizon 2020 platform for open access". Information note, 21 December. http://ec.europa.eu/research/openscience/pdf/information_note_platform_public.pdf; last accessed 22 May 2018.
- European Commission (2018). "New Commission guidance supports EU Member States in transition to Open Science", 25 April. https://ec.europa.eu/info/news/new-commission-guidance-supports-eu-member-states-transition-open-science-2018-apr-25_en; last accessed 8 May 2018.
- ERAC (2018). "ERAC SWG OSI's Assessment of the Amsterdam Call for Action", 22 February. <http://data.consilium.europa.eu/doc/document/ST-1202-2018-INIT/en/pdf>; last accessed 15 May.
- Finch, D. J. et al. (2012). "Accessibility, sustainability, excellence: how to expand access to research publications". Report of the Working Group on Expanding Access to Published Research Findings. <https://www.acu.ac.uk/research-information-network/finch-report-final>; last accessed 22 May 2018.
- Knowledge Exchange (2017). *Knowledge Exchange approach towards Open Scholarship*, August. https://repository.jisc.ac.uk/6685/1/KE_APPROACH_TOWARDS_OPEN_SCHOLARSHIP_AUG_2017.pdf; last accessed 22 May 2018.
- LERU (2010). *Harvesting talent: Strengthening research careers in Europe*. Position paper, January. <https://www.leru.org/publications/harvesting-talent-strengthening-research-careers-in-europe>; last accessed 10 May 2018.
- LERU (2011). *The LERU Roadmap Towards Open Access*. Advice paper, June. <https://www.leru.org/publications/the-leru-roadmap-towards-open-access#>; last accessed 12 February 2018.

- LERU (2012). *Research universities and research assessment*. Position paper, May. <https://www.leru.org/publications/research-universities-and-research-assessment>; last accessed 4 April 2018.
- LERU (2013). *LERU Roadmap for Research Data*. Advice paper, December. <https://www.leru.org/publications/leru-roadmap-for-research-data>; last accessed 28 January 2018.
- LERU (2014). *Tenure and tenure track at LERU universities: Models for attractive research careers in Europe*. Advice paper, September. <https://www.leru.org/publications/tenure-and-tenure-track-at-leru-universities-models-for-attractive-research-careers-in-euro-1>; last accessed 22 May 2018.
- LERU (2016a). *Maintaining a quality culture in doctoral education: At research-intensive universities*. Advice paper, March. <https://www.leru.org/publications/maintaining-a-quality-culture-in-doctoral-education-at-research-intensive-universities>; last accessed 23 May 2018.
- LERU (2016b). "Christmas is over. Research funding should go to research, not to publishers!". October. <https://www.leru.org/christmas-is-over-research-funding-should-go-to-research-not-to-publishers>; last accessed 12 February 2018.
- LERU (2016c). *Citizen science at universities: Trends, guidelines and recommendations*. Advice paper, October. <https://www.leru.org/publications/citizen-science-at-universities-trends-guidelines-and-recommendations>; last accessed 23 May 2018.
- LERU (2016d). *Society needs talent from universities: invest in human potential, particularly in early stage researchers*. Policy brief, 29 November. https://www.leru.org/files/2016_11_29_Policy_brief_Society_needs_talent_from_universities.pdf; last accessed 2 May 2018.
- LERU (2018a). *Implicit bias in academia: A challenge to the meritocratic principle and to women's careers - And what to do about it*. Advice paper, January. <https://www.leru.org/publications/implicit-bias-in-academia-a-challenge-to-the-meritocratic-principle-and-to-womens-careers-and-what-to-do-about-it>; last accessed 10 May 2018.
- LERU (2018b). *Delivering talent: careers of researchers inside and outside academia*. Position paper, June.
- MacCallum, C. (2018). "Research Communication: Open Science & the perverse evaluation cycle", presentation delivered at the UCL Press – Open Access Megajournal Project Town Hall event, 16 January, London. <https://doi.org/10.14324/111.1234>; last accessed 23 May 2018.
- Moedas, C. (2015). "Open Innovation, Open Science, Open to the World", Speech, 22 June. http://europa.eu/rapid/press-release_SPEECH-15-5243_en.htm; last accessed 7 May 2018.
- Mons, B. et al. (2016). Realising the European Open Science Cloud. First report and recommendations of the Commission High Level Expert Group on the European Open Science Cloud, European Union. <https://doi.org/10.2777/940154>; last accessed 25 May 2018.
- O'Carroll, C. et al. (2017a). *Evaluation of Research Careers fully acknowledging Open Science Practices; Rewards, incentives and/or recognition for researchers practicing Open Science*. Report written by the Working Group on Rewards under Open Science, European Union, July. <https://doi.org/10.2777/75255>; last accessed 28 May 2018.
- O'Carroll, C. et al. (2017b). *Providing researchers with the skills and competencies they need to practise Open Science*. Report of the Working Group on Education and Skills under Open Science, European Union, July. <https://doi.org/10.2777/121253>; last accessed 25 May 2018.

- Ritter, M. (2017). "Open science and research integrity". In Soete, L. et al. (2017) *Europe's future-open innovation, open science, open to the world : reflections of the Research, Innovation and Science Policy Experts (RISE) High Level Group*, European Union, May. <https://doi.org/10.2777/79895>; last accessed 28 May 2018.
- Schade, S. et al. (2017). "Scientific data from and for the citizen", *First Monday*, July. <http://dx.doi.org/10.5210/fm.v22i8.7842>; last accessed 25 May 2018.
- Schiermeier, Q. (2017). "Hundreds of German universities set to lose access to Elsevier journals. Negotiations to reduce journal prices and promote open access are progressing slowly", *Nature*, 5 December. <https://www.nature.com/articles/d41586-017-07817-1>; last accessed 22 May 2018.
- Science Europe (2015). *Research Integrity: What it Means, Why it Is Important and How we Might Protect it*. Briefing Paper, December. http://www.scienceeurope.org/wp-content/uploads/2015/12/Briefing_Paper_Research_Integrity_web.pdf; last accessed 23 May 2018.
- Science Europe (2018). *Presenting a Framework for Discipline-specific Research Data Management*. Guidance document, January. https://www.scienceeurope.org/wp-content/uploads/2018/01/SE_Guidance_Document_RDMPs.pdf; last accessed 22 May 2018.
- Wilkinson, M.D. et al. (2016). "The FAIR Guiding Principles for scientific data management and stewardship", *Scientific Data* 3, 15 March. <https://doi.org/10.1038/sdata.2016.18>; last accessed 28 May 2018.
- Wilsdon, J., et al. (2015). *The Metric Tide: Report of the Independent Review of the Role of Metrics in Research Assessment and Management*. <https://doi.org/10.13140/RG.2.1.4929.1363>; last accessed 28 May 2018.
- Wilsdon, J.R. et al. (2017). *Next-generation metrics: Responsible metrics and evaluation for open science*. Report of the European Commission Expert Group on Altmetrics, European Union, March. <https://doi.org/10.2777/337729>; last accessed 28 May 2018.

Appendix 1 - Recommendations

In order to benefit from the opportunities -and rise up to the challenges- that Open Science brings to universities, LERU puts forward a set of recommendations in each of the priority areas identified by the European Commission. These recommendations are based on the experiences of the LERU members in dealing with Open Science and are intended to serve as a roadmap for universities to take Open Science forward. Although derived from the experience of LERU members, these recommendations can also chart the course of action for *any* university. Open Science represents a complex and multi-dimensional process of transition, different for every university. The recommendations in this LERU paper do not represent a prioritisation of topics, nor an exhaustive list of actions to be taken by universities. They, and the paper as a whole, are intended to serve as a roadmap to accompany universities' efforts towards embracing Open Science, leaving room for each institution to carve out its own path, strategy and actions. Below are LERU's recommendations for universities on cultural change and the eight dimensions of Open Science.

Cultural change

1. Appoint a senior manager to lead Open Science approaches across all 8 pillars of the Open Science debate identified by the European Commission.
2. Develop a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings.
3. Establish advocacy programmes, which should identify the benefits of Open Science approaches, whilst being realistic about the challenges.
4. Draw up a communication strategy, which enables the whole university body to become familiar with Open Science practices.

The future of scholarly communication

5. Have institutional mandates to support the move to full Open Access, whose implementation can be monitored regularly.
6. Deliver a roadmap for how they, or specific groupings, can develop agreed plans for the future of scholarly publishing in their institution.
7. Advocate the use of author identifier systems such as ORCID across their institution.
8. Consider supporting new forms of scholarly publishing from third parties dedicated to Open Access approaches.
9. Where appropriate, establish new mechanisms for scholarly publishing based on the good practice identified in this paper.

FAIR data

10. Adopt or update an institutional policy on research data management -ideally modelled on the template produced by LEARN⁶¹-, embracing the FAIR principles and based on an 'as open as possible, as closed as necessary' philosophy, and establish a dedicated committee on research data management to monitor the implementation and uptake of such a policy.
11. Design and establish services for data stewardship, provide researchers with suitable infrastructures, and identify funding and resources to archive and to publish data.
12. Create a catalogue of where researchers have published data (or stored if not available for any reason)- as is currently done with publications, and consider how to use this information in any research assessment or evaluation (cf. recommendations on rewards).
13. Provide free access to metadata in order to facilitate the discovery of data for which access must be restricted because of privacy, security, or confidentiality issues, making sure such metadata fulfil the FAIR principles, and establishing a grade of accessibility to those restricted research data.⁶²

61 LEARN Research Data Management toolkit: <http://learn-rdm.eu/en/research-data-management-toolkit-now-available/>; last accessed 7 May 2018.

62 An example of degrees of access for sensitive research data is available at <http://datatags.org>; last accessed 17 April 2018.

14. Establish training sessions on research data management at all levels, starting from students (cf. recommendations on education and skills).
15. Work together with any local, national or international activities, using for instance Research Data Alliance national groups⁶³ or the Digital Curation Centre's Data Management Planning Tool.⁶⁴

The EOSC

16. Ensure institutional access to the requisite infrastructure, such as a locally managed data repository where research data is available for sharing and reuse, or that they ensure researchers understand where third-party storage solutions are available, which can themselves be part of the EOSC.
17. Provide a search and discovery service, enabling users to find what research data is available and where it is located, as it is key to the wider use of such resources and, therefore, of the vision embodied in the EOSC.
18. Move to sign the EOSC Declaration over time, as a statement of commitment at a local level, as LERU has done as an international network.
19. Develop their research data management offering so that it is aligned with the principles of engagement with the EOSC, once the latter are agreed and available, and in the expectation that the EOSC develops a more customer-centric approach to stakeholder outreach, which would facilitate engagement with researchers, academic support staff and service providers at universities in the development of its services.

Education and skills

20. Integrate Open Science concepts, thinking, and its practical applications in educational and skills development programmes, analysing and mapping their needs for Open Science skills training, taking into account the different Open Science dimensions and the varying needs of different audiences, different disciplines, etc.
21. Encourage, incentivise, support and recognise staff and students with regard to Open Science skills development.
22. Determine how to resource Open Science skills training in a sustainable manner.
23. Monitor the take-up and impact of Open Science skills training to determine progress towards its cultural integration in the institution.
24. Explore innovative mechanisms and tools to provide Open Science skills training, and engage with others outside the university to exchange good practice.

Recognition and rewards

25. Endeavour to integrate Open Science dimensions in their HR and career frameworks as an explicit element in recruitment, performance evaluation and career advancement policies, so that research and teaching staff are appropriately recognised and rewarded for practicing Open Science.
26. Develop institutional policies for recognising and rewarding Open Science practice anchored in broad-based support; communicate them clearly and transparently, make them easy to find and access, and provide proper guidance or training to those who are involved in staff recruitment, appraisal and promotion in the university.
27. Develop individual HR criteria for recognising and rewarding Open Science in job descriptions, performance appraisals and promotion criteria, for all or most research and teaching staff, which take into account their multiple responsibilities, in terms of research output, process, impact, teaching and supervision, leadership, service to the university, public engagement, professional experience, as well as considering collaborative and team accomplishments in addition to individual accomplishments when appropriate.

63 Research Data Alliance: <https://www.rd-alliance.org/groups/national-groups>; last accessed 17 April 2018.

64 The Digital Curation Centre's Data Management tool: <http://www.dcc.ac.uk/resources/data-management-plans>; last accessed 7 May 2018. For Finnish examples, see DMPTuuli at <https://www.dmptuuli.fi/>; last accessed 17 April 2018: a Data Management Planning tool Tuuli which helps in the construction of data management plans. See also the work by Universities Finland UNIFI (a co-operative organisation for Finnish universities), in particular its Open Science and Data Action Plan Project; see <http://www.unifi.fi/in-english/>; last accessed 17 April 2018.

28. Embed Open Science principles in the institutional research assessment system⁶⁵, shifting away from an excessive reliance on publication-based journal impact factors and citation cultures and recognising Open Science approaches such as OA publishing, data/code/reagent sharing, recognising pre-prints, etc.
29. Offer appropriate support, professional development and training opportunities for Open Science, aligned with employees' different needs depending on discipline, career progression, seniority and goals, including moving outside the university (cf. recommendations on education and skills).
30. Periodically monitor, reflect on and update their Open Science rewards system so it remains fresh and fit-for-purpose.

Next-generation metrics

31. Develop a bibliometrics policy grounded in the principles of the Leiden Manifesto, with the aim of changing the culture in the academic community about research assessment.
32. Embed the new forms of research evaluation in its internal processes for promotion/reward and research evaluation.
33. Construct, via appropriate internal bodies, guidance for research administrators and academics on good and bad practice in the use of traditional bibliometrics and in the development of new metrics, and that they work with the scientific community in this endeavour.
34. Provide training to junior researchers, particularly early-stage doctoral researchers, enabling them to embrace the change of culture and practice which the responsible use of metrics brings (cf. recommendations on education and skills).

Research integrity

35. Promote and develop awareness amongst the research community of how Open Science can ensure the highest standards of research.
36. Have a research integrity code which embraces the principles of open science or that they abide by the European Code for Research Integrity (ALLEA Code), in which, next to general principles of reliability, honesty, respect and accountability, good research practice includes inter alia:
 - a. Research institutions rewarding open and reproducible practices in hiring and promotion of researchers (cf. recommendations on recognition and rewards);
 - b. Authors ensuring that their work is made available to colleagues in a timely, open, transparent, and accurate manner, unless otherwise agreed;
 - c. Making research data as open as possible, as closed as necessary, in line with the FAIR principles for research data management;
 - d. Partners in research collaborations agreeing at the outset on the goals of the research and on the process for communicating their research as transparently and openly as possible;
 - e. Researchers adhering to the same criteria whether they publish in a subscription journal, an open access journal or in any other alternative publication form.

Citizen science

37. Recognise citizen science as an evolving set of research methods, as well as its societal and educational benefits.
38. Consider creating, where viable, a single point of contact for citizen science within the institution.
39. Raise awareness amongst researchers of criteria for successful citizen science and ensure compliance with ethical, legal and privacy regulations.
40. Develop ways of assessing citizen science contributions and adapt research evaluation and reputation systems accordingly.
41. Ensure that proposals to granting bodies for citizen science projects include long-term commitment for infrastructures and data repositories.

65 The Open Science Career Assessment Matrix (OS-CAM), proposed by the EU Working Group on Open Science Rewards, may provide a useful starting point to develop an institutional system. See https://ec.europa.eu/research/openscience/pdf/os_rewards_wgreport_final.pdf

Appendix 2 - Checklist of questions for universities

This appendix provides a set of questions which universities can use to monitor their progress in implementing Open Science principles, practices and policies at a local level. Each of the 37 questions is drawn from the recommendations in the paper and, taken together, the answers to the questions will provide a compelling narrative regarding universities' progress in the Open Science agenda. The questions can be used iteratively to monitor performance periodically (preferably annually), so that progress can be identified and remaining priorities established. The RAG system (red-amber-green) can be used to assess how the university is (or sub-units are) progressing towards a goal, with green indicating activity in progress to being completed, amber meaning that some progress is made, but challenges remain, and red denoting that the activity has not been delivered and there are no plans to deliver such an outcome.

	Topic	Question	Assesment of progress	RAG Status
Cultural change				
1.	Leadership	Has your university appointed a senior manager to lead Open Science approaches across all eight pillars of the Open Science debate identified by the European Commission?		
2.	HR	Has your university developed a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings?		
3.	Advocacy	Does your university have advocacy programmes to identify the benefits of Open Science approaches, whilst being realistic about the challenges?		
4.	Communication	Does your university have communication strategies which enable the whole university body to become familiar with Open Science practices?		
The future of scholarly publishing				
5.	Compliance	Does your university have institutional mandates to support the move to full Open Access and does it monitor implementation of these mandates?		
6.	Planning	Can relevant stakeholders work together to deliver a roadmap for how they, or specific groupings, can develop agreed plans for the future of scholarly publishing in their institution?		
7.	Advocacy	Does your university advocate the use of author identifier systems such as ORCID across the institution?		
8.	Innovation	Has your university considered supporting new forms of scholarly publishing from third parties, such as OpenEdition and Knowledge Unlatched, which are dedicated to Open Access approaches?		
9.	Innovation	Where appropriate, has your university established new mechanisms for scholarly publishing based on the good practice identified in this chapter?		

Open Science and its role in universities

	Topic	Question	Assesment of progress	RAG Status
FAIR data				
10.	Institutional policy	Has your institution a research data policy or strategy?		
11.	Institutional policy	Does your institution research data policy or strategy include FAIR principles?		
12.	Institutional support	Has your institution established a dedicated service to provide data stewardship to its researchers?		
13.	Infrastructure	Does your institution provide access to an infrastructure storage and publication of research data ? If it does not, does your institution inform its researchers of available infrastructures that follow the FAIR principles?		
14.	Data	Does your institution gather information about the data archived and published by its research community?		
15.	Metadata	Does your institution publish all metadata about research data generated or obtained within its research community?		
16.	Assessment	Does your institution include research data as a valuable output in research assessments?		
The European Open Science Cloud				
17.	Infrastructure development	Has your university established a data repository, or does it have access to a 3rd party repository/repositories which can interact with the EOSC?		
18.	Infrastructure development	Does your university have a search and discovery service, enabling users to find what research data is available, and where it is located?		
19.	Policy development	Has your university signed the EOSC Declaration as a statement of commitment at a local level?		
20.	Co-operation and collaboration	Will your university develop their research data management offering so that it is aligned with the principles of engagement with the EOSC, once the latter are agreed and available?		
Education and skills				
21.	Training	Does your institution offer skill straining specifically in Open Science (in all or certain of the eight areas, or other Open Science aspects)?		
22.	Audience	Is any Open Science skills training mandatory, and for which categories of staff/researchers/students?		
23.	Assessment	Does your institution monitor or assess the provision, uptake and impact of Open Science skills training?		
Recognition and rewards				
24.	HR policy	Does your institution integrate Open Science in its HR and career frameworks as an explicit element in recruitment, performance evaluation and career advancement policies?		
25.	Assessment	Does your institution assess the extent to which individuals, teams or units integrate Open Science in their daily practice? And does it recognize and/or rewards them for this?		
26.	Communication	Does your institution make information about its policies on researcher evaluation open and easily accessible?		

	Topic	Question	Assesment of progress	RAG Status
Next-generation metrics				
27.	Policy development	Will your university develop a bibliometrics policy grounded in the principles outlined in this paper, with the aim of changing the culture in the academic community about research assessment?		
28.	HR	Will your university embed the new forms of research evaluation in its internal processes for promotion/reward and research evaluation?		
29.	Best practice guidance	Will your university, via appropriate internal bodies, construct guidance for research administrators and academics on good and bad practice in the use of traditional bibliometrics and in the development of new metrics, working with the scientific community in this endeavour?		
30.	Training for early career researchers	Will your university give particular focus to early career researchers, particularly those embarking on a course of doctoral study, providing training to enable them to embrace the change of culture and practice which the responsible use of metrics brings?		
Research integrity				
31.	Communication	Does your institution promote awareness amongst the research community of how Open Science can ensure the highest standards of research?		
32.	Policy	Does your university have a research integrity code which embraces the principles of Open Science? If not, does your institution abide by the European Code for Research Integrity (ALLEA Code) and the Open Science provisions it contains?		
Citizen science				
33.	Policy	Does your university recognise citizen science as an evolving set of research methods, as well as its societal and educational benefits?		
34.	Communication	Is there a single point for citizen science within your institution?		
35.	Communication	Does your university raise awareness amongst researchers of criteria for successful citizen science?		
36.	Assessment	Are citizen science contributions assessed and research evaluation and reputation systems adapted accordingly?		
37.	Policy	Do proposals for granting bodies for citizen science projects include long-term commitment for infrastructures and data repositories?		



PUSHING
THE FRONTIERS
OF INNOVATIVE
RESEARCH

University of Amsterdam

Universitat de Barcelona

University of Cambridge

University of Copenhagen

Trinity College Dublin

University of Edinburgh

University of Freiburg

Université de Genève

Universität Heidelberg

University of Helsinki

Universiteit Leiden

KU Leuven

Imperial College London

University College London

Lund University

University of Milan

Ludwig-Maximilians-Universität München

University of Oxford

Sorbonne University

Université Paris-Sud

University of Strasbourg

Utrecht University

University of Zurich

LERU Office

Minderbroedersstraat 8
3000 Leuven
Belgium

tel +32 16 32 99 71
info@leru.org
www.leru.org

 @LERUnews