



Review Article

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Defining the role of libraries in the Open Science landscape: a reflection on current European practice

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Abstract: This collaborative paper looks at how libraries can engage with and offer leadership in the Open Science movement. It is based on case studies and the results of an EU-funded research project on Research Data Management taken from European research-led universities and their libraries. It begins by analysing three recent trends in Science, and then links component parts of the research process to aspects of Open Science. The paper then looks in detail at four areas and identifies roles for libraries: Open Access and Open Access publishing, Research Data Management, E-Infrastructures (especially the European Open Science Cloud), and Citizen Science. The paper ends in suggesting a model for how libraries, by using a 4-step test, can assess their engagement with Open Science. This 4-step test is based on lessons drawn from the case studies.

Keywords: Open Science, Open Access, Research Data Management, RDM, Open Access Publishing, EOSC, European Open Science Cloud, Citizen Science

1 Methodology

The purpose of this paper is to draw a roadmap to show how libraries can engage in the Open Science agenda. It will do this by examining a number of key issues. First, it looks at the scope of Open Science and identifies three major shifts in practice. It then maps out an idealised work flow for the research process and maps certain key elements of Open Science to that work flow. It then looks at individual subject themes: Open Access, Research Data Management, the European Open Science Cloud, and Citizen Science. These areas have been chosen because they form key elements of the EC's Open Science Policy Platform definition of Open Science¹ and because these are areas where LERU (League of European Research Universities) has written advice papers or contributed to reports.² From the emerging discourse on inclusiveness in Open

¹ European Commission: <https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform>; last accessed 18 December 2017.

² LERU: <https://www.leru.org/files/The-LERU-Roadmap-Towards-Open-Access-Full-paper.pdf> for Open Access; last accessed 18 December 2017; <https://www.leru.org/files/LERU-Roadmap-for-Research-Data-Full-paper.pdf> for Research Data Management; last accessed 18 December 2017; <https://www.leru.org/files/Citizen-Science-at-Universities-Trends-Guidelines-and-Recommendations-Full-paper.pdf> for Citizen Science; last accessed 18 December 2017; For the EU-funded LEARN project on Research Data Management, see n. 16; https://ec.europa.eu/research/openscience/pdf/realising_the_european_open_science_cloud_2016.pdf#view=fit&pagemode=none for the High Level Expert Group Report on the European Open Science Cloud, last accessed 18 December 2017.

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Science, it is clear that Open Science is a global event.³ For this article, nonetheless, the context of the discussion is European. The authors end by drawing a number of conclusions on the role that libraries can assume in the brave new world of Open Science, based on the case studies and the EU-funded project they have analysed.

2 Three Major Shifts in Science

Science is in continuous transformation. Probably the only constant element here is the change itself. Some may see scientific work as being very traditional, but in fact science is inducing society to change at a fast pace.

There are three major shifts that we can consider (Nielsen, 2013) when we look to the current transformation of science. We will give a concise list of them here, for establishing the present-day environment in which Open Science develops.

- *How scientists collaborate to create knowledge.* There are new methods, tools, mandates and recommendation that transform the way researchers unite today to accelerate discovery. Research Data Management, the European Open Science Cloud, the European Research Area and the European Research Infrastructure Consortia - to name a few - are part of this shift.
- *How scientists find meaning in knowledge.* This shift is harder to describe, but we can give here the example of The International HapMap Project. This is a project in genetics, completed in 2007, that charts genetic variations in the entire human race (The International HapMap Consortium, 2005). Creating the HapMap is making knowledge. Connecting this new knowledge with human disease gives it great meaning. In other words, we are experiencing a significant growth in scientists' skills sets to find meanings in knowledge.
- *A change in the relationship between Science - Society.* It is more and more a concern of both scientists and the rest of society to build a relationship based on common goals, high ethical standards, open and effective communication, recorded achievements, transparency and a measurable return of investment. Open Access, Citizen Science, Science Open Days and Pop Science are just some examples of Open Science that are part of this shift.

3 Open Science: its scope

Open Science is the movement to make scientific research, data and dissemination accessible at all levels of an enquiring society. As such it represents a sea change in the way research is conducted, recorded and disseminated. Open Science is therefore a paradigm shift in the modus operandi of research and science impacting the entire scientific process.

Figure 1 shows how this impact works. On the left-hand side of the diagram, individual components of the research process are listed – *conceptualization* of an idea, *data gathering* to prove the concept, *analysis* of all the inputs into the study, *peer review* of the findings and finally *publication* of the outputs. On the right-hand side are listed component parts of the Open Science agenda which could feed into the research process:

- Open Access to publications
- Open source code
- Pre-prints in Green Open Access repositories
- Open Peer review
- Alternative Reputation Systems, based on new/alternative metrics
- Collaborative Bibliographies
- Science Blogs

³ See, for example, the Open Science Manifesto at <https://ocsdnet.org/manifesto/open-science-manifesto/>; last accessed 18 December 2017.

- Open Annotation
 - Open Data
 - Open Lab Books/Workflows
 - Citizen Science
- This article has chosen to investigate 4 themes further:
- Open Access and Open Access Publishing
 - Research Data Management
 - E-Infrastructures, especially the European Open Science Cloud
 - Citizen Science

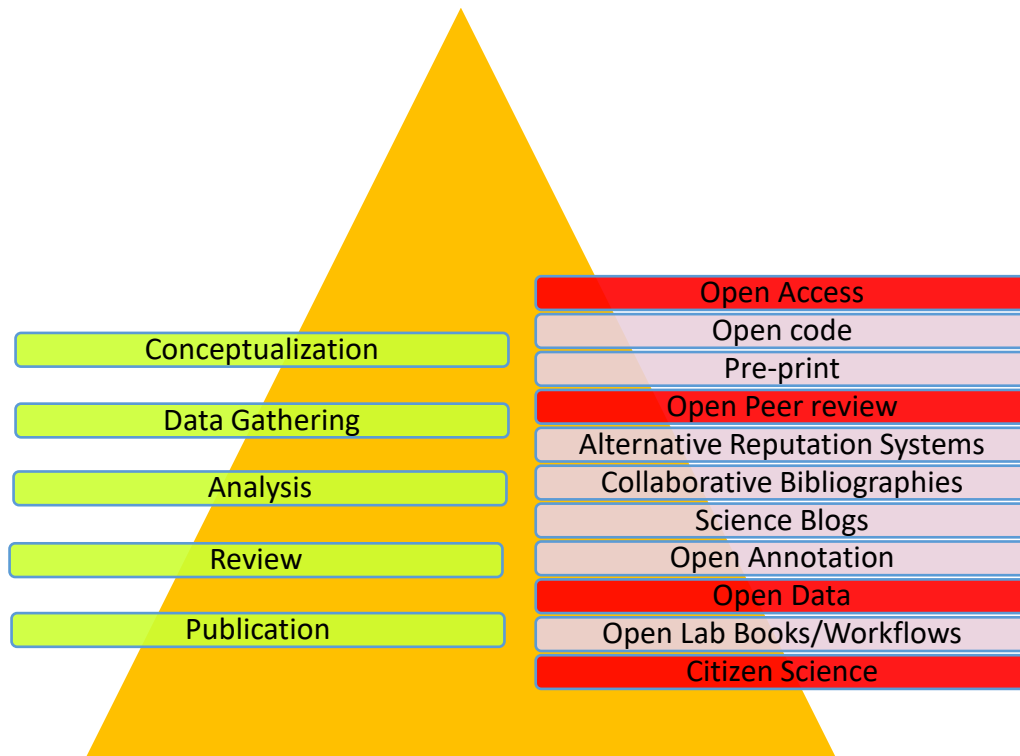


Figure 1: The research cycle mapped against component parts of Open Science

These are areas which figure prominently in the European Commission's analysis of Open Science and LERU's (League of European Research Universities) analysis of where libraries can make a contribution in the Open Science debate.⁴

We presented our ideas to audiences at 9 events based in research intensive organisations: LIBER Annual Conference (Patras, Greece), Meeting at Leeds University Library (Leeds, UK), Repository Fringe 2017 (Edinburgh, UK), SpringerNature - CARE Research Day (Rome, Italy), UKSG One-Day Conference (London, UK), Focus on Open Science: Chapter I (Vienna, Austria), Focus on Open Science: Chapter II (Budapest, Hungary), Focus on Open Science: Chapter III (Ljubljana, Slovenia), and a Meeting of Irish librarians, administrators and researchers (Dublin, Ireland). These meetings confirmed that the 4 elements were well chosen, producing engagement with the audience and their respective institutions.

What is the role of the Library in these spaces? What is best practice in each of these areas? Are there Libraries who have made important contributions? This article will now attempt to answer those questions.

⁴ For sources, see nn. 1 and 2.

4 Open Access

4.1 Open Access policies

The area of Open Science in which research institutions have actively engaged is Open Access (OA). The Registry of Open Access Repository Mandates and Policies (ROARMAP) charts the growth of such documents. By the second quarter of 2017, ROARMAP had identified 880 policies from across the world. The taxonomy breaks the policies down according to the body issuing them:

- Research organisation
- Funder
- Sub-unit of research organisation
- Funder and research organisation
- Multiple research organisations

The results can be seen in Figure 2 below.

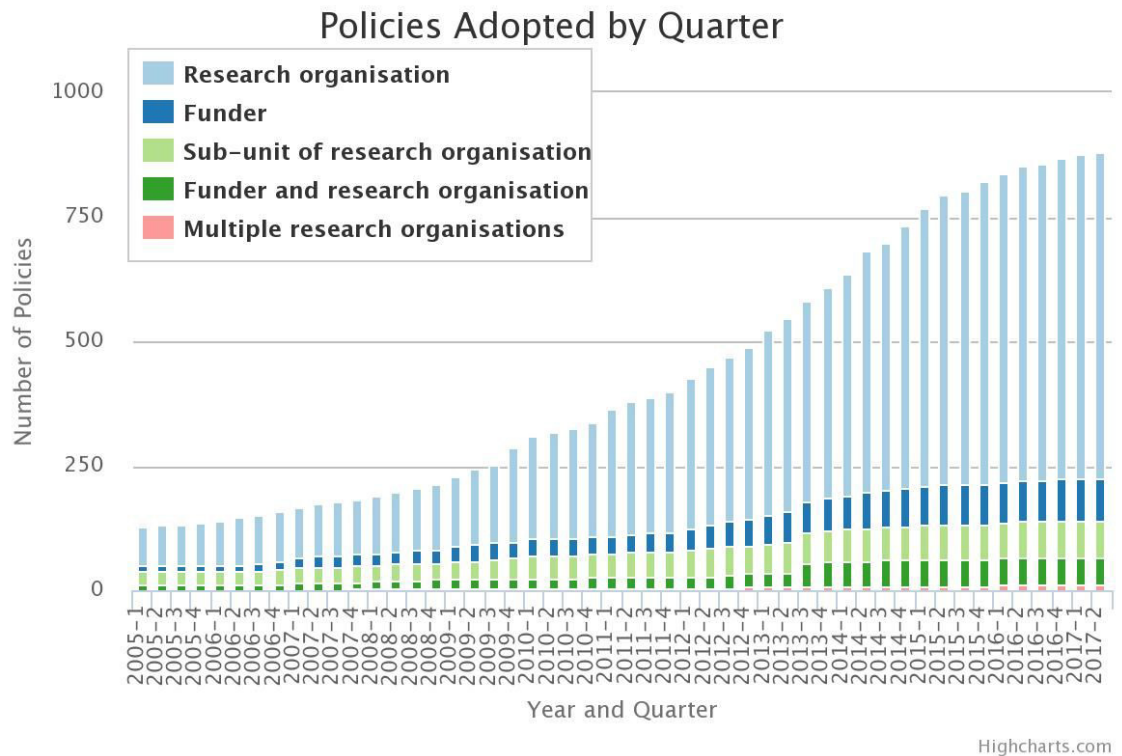


Figure 2: Number of Open Access policies worldwide. Data: ROARMAP⁵ (Registry of Open Access Policies and Mandates) Q1 2005 – Q2 2017

880 represent a lot of separate policies. Is there really a need for a Tower of Babel, with so many different policies to choose from? Europe has more than anyone else, as Table 1 makes clear.

⁵ ROARMAP: <http://roarmap.eprints.org/>; last accessed 9 August 2017.

Table 1: Global Open Access policies. Data: ROARMAP.

Region	Policies
Europe	543
Americas	214
Africa	24
Asia	58
Oceania	41
TOTAL	880

The multiplicity of policies, overlaps and contradictions has every ingredient for producing confusion amongst academic researchers. This is clear from the pattern of policy provision in the UK. Like many universities, UCL Library Services (University College London) has constructed a website to guide UCL authors on how to comply with funder requirements regarding open access.⁶ There are 39 entries in the Table – so complex is the web of requirements that UK researchers are supposed to meet. Library support for delivering Open Access is seen as crucial in the institution, not least because the funder policies are not all aligned and this confuses researchers. Research Councils UK (RCUK) for example has a preference for Gold Open Access and will pay reasonable Open Access publication charges (RCUK Policy, 2013): “*The Research Councils UK (RCUK) policy supports both ‘Gold’ and ‘Green’ routes to Open Access, though RCUK has a preference for immediate Open Access with the maximum opportunity for reuse.*” HEFCE (Higher Education Funding Council for England) has a policy with a different nuance:⁷

*“The policy states that, to be eligible for submission to REF 2021, authors’ outputs must have been deposited in an institutional or subject repository. Deposited material should be discoverable, and free to read and download, for anyone with an internet connection.”*⁸

While the HEFCE policy is permissive of any approach to Open Access which meets its objectives, there is a requirement for an Open Access version of every output submitted to the REF evaluation to be present in your institutional or a subject repository. REF, the Research Evaluation Framework, has the potential to be a game changer in the UK in terms of researchers’ willingness to embrace Open Access. REF, which has taken place every 5 to 7 years since 1986, is the basis for which nearly £2 billion research funding is allocated every year. REF is therefore of tremendous importance to UK Higher Education and can shape the behaviour of researchers in how and where they publish.

4.2 UCL Library Services leading institutionally on Gold Open Access

The profusion of policies means that the Open Access Team in UCL Library Services plays a pivotal role in the takeup of OA across the institution.

Figure 3 shows the total number of Article Processing Charges (APCs) paid by UCL Library Services on behalf of the UCL academic community over a 4-year period (April 2013-March 2017). The total is 8,661 – of which 3,641 were paid by RCUK funding, and 2,103 by funds from the Wellcome Trust and associated charity funders (COAF). The remaining 2,917 APC payments were made by UCL from funding the institution itself provided.

In a country such as the UK with a plethora of OA policies, it is essential that any institution has control over its OA funding sources and that it can advocate best practice to researchers across the institution. In UCL, as in many other UK research-intensive universities, it is the Library that has been given this role.

⁶ UCL: <http://www.ucl.ac.uk/library/open-access/>; last accessed 13 June 2017.

⁷ HEFCE: <http://www.hefce.ac.uk/rsrch/oa>; last accessed 13 June 2017.

⁸ HEFCE: <http://www.hefce.ac.uk/pubs/year/2016/201635>; last accessed 13 June 2017.

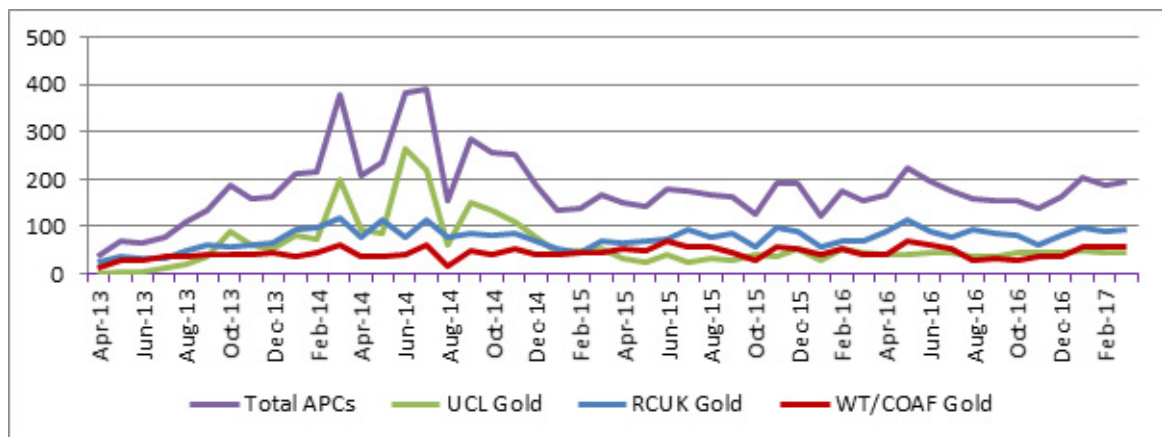


Figure 3: Total Article Processing Charges paid via UCL Library Services, April 2013-March 2017

4.3 UCL and Green Open Access

The success of Green Open Access at UCL can be seen in Table 2 below. IRUS-UK collects raw usage data from UK repositories and processes these into ‘COUNTER-compliant’, comparable statistics. (COUNTER is a standard for measuring usage in academic publishing). UCL became an IRUS partner in March 2016. The table shows IRUS download rankings for April 16 - April 17, measured at 9 May 2017.

Table 2: IRUS-UK statistics on UK repository downloads April 2016-April 2017

	Number of downloads April 16-April 17	Full text records in repository	Average downloads per item April 16- April 17
1 UCL Discovery	2,269,287	38,539	59
2 LSE Research Online	2,187,193	23,699	92
3 University of Southampton - ePrints Soton	2,166,472	47,056	46
4 White Rose Research Online	1,302,014	43,252	30
5 Loughborough University Institutional Repository	1,118,511	23,868	47
Selected others			
6 Apollo - University of Cambridge Repository	997,569	38,110	26
16 Spiral: Imperial College Digital Repository	743,099	43,811	17
17 Nottingham ePrints	701,706	20,502	34
18 Edinburgh Research Archive	678,014	20,943	32

Table 2 shows that UCL Discovery, the UCL repository, currently experiences more downloads than any other UK repository mapped by IRUS-UK. Figure 4 shows the most downloaded items from UCL Discovery in the first quarter of 2017.

It is important to note that 3 of the top 10 downloads, numbers 3, 4 and 9 are doctoral theses. UCL Library Services has championed a change in UCL Regulations, to the effect that every PhD granted by UCL should have a digital copy in UCL Discovery. Whether it is made Open Access is at the request of the student, who owns the copyright.⁹

⁹ UCL: <http://www.ucl.ac.uk/library/e-theses>; last accessed 13 June 2017.

	Title	Downloads
1	Miller, D; Costa, E; Haynes, N; McDonald, T; Nicolescu, R; Sinanan, J; Spyer, J; (2016) How the World Changed Social Media. [Book]. Why we post. UCL Press: London, UK	8,214
2	Biel, RA; (2016) Sustainable Food Systems. [Book]. UCL Press: London	4,939
3	Pheng, L.S.; (1990) Marketing theories and concepts for the international construction industry: a study of their applicability at the global, national and corporate perspectives. Doctoral thesis, University of London	4,660
4	Brennan, F.P.; (1992) Fatigue and fracture mechanics analysis of threaded connections. Doctoral thesis, University of London	2,698
5	Miller, D; Sinanan, J; (2017) Visualising Facebook. [Book]. Why We Post. UCL Press: London.	2,686
6	Brügger, Niels and Schroeder, Ralph (Eds). (2017) The Web as History. [Book]. UCL Press: London.	2,347
7	Sharp, H.; Finkelstein, A.; Galal, G.; (1999) Stakeholder identification in the requirements engineering process. In: Proceedings of 10th International Workshop on Database & Expert Systems Applications (DEXA). (pp. 387-391). IEEE Computer Society Press	2,304
8	Tilley, CY; Cameron-Daum, K; (2017) An Anthropology of Landscape. [Book]. UCL Press: London	2,234
9	Fletcher, T.S.B.; (2012) Machine learning for financial market prediction. Doctoral thesis, UCL (University College London)	2,225
10	Steadman, P; (2006) Why are most buildings rectangular? Architectural Research Quarterly , 10 (2) pp. 119-130	2,078

Figure 4: Downloads from UCL Discovery, Quarter1 2017

5 Open Access Publishing: UCL Press

Open Access publishing presents a series of opportunities for libraries and, in UCL, this has been taken forward by the Library with a bold new venture – the creation of UCL Press (Figure 5) as the UK’s first fully Open Access University Press. UCL Press is a department of UCL Library Services and the Pro-Vice-Provost (UCL Library Services) acts as Chief Executive Officer of UCL Press.



Figure 5: UCL Press Logo

The idea to establish the Press as an Open Access Press emanated from the Library as a response to the challenge which Open Access presents to authors – particularly authors of monographs, which are a format not covered either by the RCUK or the HEFCE mandates.

The Mission and Vision for the Press¹⁰ make clear that the publishing activity, based in the Library, is meant to deliver disruptive change: *“To embed and explore Open Access approaches as the principal means of dissemination for academic work in a digital world”*.

¹⁰ UCL Press: <http://www.ucl.ac.uk/ucl-press/about>; last accessed 14 June 2017.

5.1 Organisational structure of UCL Press

In terms of organisation, UCL Press has the following structure which is shown in Figure 6:

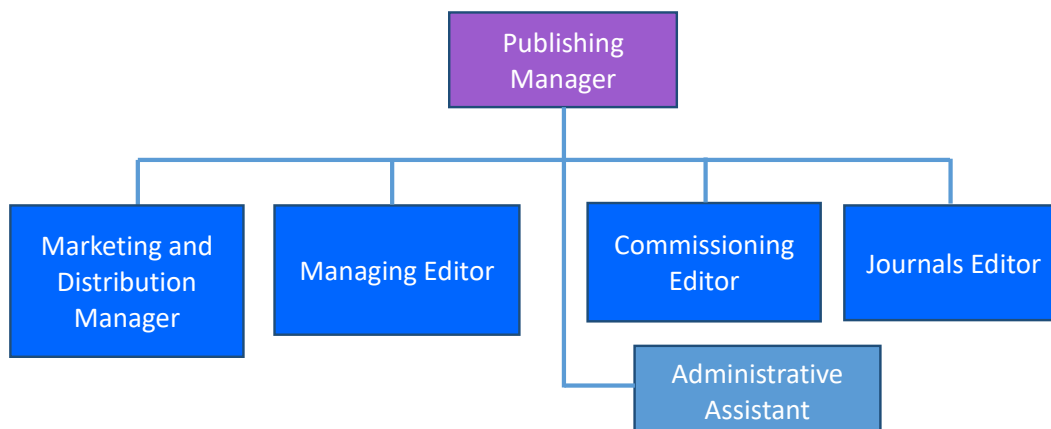


Figure 6: Organisational structure of UCL Press

5.2 Impact of UCL Press

UCL Press was founded as an Open Access Press in June 2015,¹¹ and in the first 23 months has published 33 books. The Press started with monograph publishing because it wanted to make a difference for Arts, Humanities and those Social Sciences where monograph publishing is the main form of output. Both the RCUK and HEFCE OA mandates exempt monographs from coverage, in the recognition that there are currently relatively few outlets for OA monograph publishing. UCL Press wants to change that.

The download and impact statistics for Press publications June 2015 – May 2017 tell a revealing story (Table 3).

Table 3: UCL Press statistics, June 2015-May 2017

UCL Press Books (all platforms)	Measure
Number of monographs published	31
Total OA downloads	369,089; average 11,906 per title
Total print sales	3,972; average 128 per title
Countries reached	203

In the 2 years of operation to May 2017, UCL Press has published 31 monographs mainly (but not exclusively) in the Arts, Humanities and Social Sciences. The total number of downloads from the 3 platforms – UCL Discovery, OAPEN and JSTOR – amount to just under 370,000 from 203 countries. This gives an average download figure per title (to May 2017) of 11,906. The books are available as PDFs from the relevant storage platform. The Press has also developed an enhanced digital reader, which is currently available only for certain titles, e.g. *Treasures from UCL*.¹²

¹¹ UCL Press: <http://www.ucl.ac.uk/ucl-press>; last accessed 13 June 2017.

¹² UCL Press: <http://www.ucl.ac.uk/ucl-press/browse-books/treasures-from-ucl>; last accessed 19 December 2017.

5.3 Creative Commons and Book Publication Charges

The default licence, which authors are advised to adopt, is Creative Commons CC-BY. All these materials are therefore freely available in Open Access to anyone in the world with an Internet connection. UCL will pay all publication charges for UCL authors. For external authors, there is a Book Publication Charge, which is currently £5,000 for books of up to 100,000 words.¹³ As well as Open Access, digital copy readers can choose to purchase a Print-on-Demand paper copy. Sales average just under 130 per title, a respectable figure.

5.4 Innovative Textbook offering

One of the innovative features of UCL Press is its Open Textbook offering. The Press has currently published 2 textbooks – [Textbook of Plastic and Reconstructive Surgery](#)¹⁴ and [Key Concepts in Public Archaeology](#).¹⁵ UCL Press sees Open Access textbooks as a key deliverable to support its new Education Strategy.¹⁶ This strategy sees the creation of an Open Educational Resources repository as a key deliverable. This is where UCL's Open Educational Resources will reside and UCL Press has issued a call to UCL academics for 10 Open Access textbooks to seed the development.

5.5 New role for the Library

As a library-based publisher, UCL Press has developed a new role for the Library in the dissemination of research and educational outputs. As a result of such activity, the Library is now more than a curator and cataloguer of knowledge. The Library has now become an active creator of knowledge. That new role places the Library squarely in the front of advances at an institutional level to develop new approaches to the delivery of Open Science.

6 Research Data Management - LEARN

As Figure 1 shows, research data management (particularly open data) is a vital component of the Open Science agenda. The theme of research data management (RDM) was taken forward in an EU-funded project called LEARN – **LE**aders **A**ctivating **R**esearch **N**etworks.¹⁷ There were five partners – UCL (University College London), University of Barcelona, University of Vienna, LIBER and ECLAC (Economic Commission for Latin America and the Caribbean). The objective of LEARN was to take the [LERU Roadmap for Research Data](#) (Achard et al., 2013) and to see how far stakeholders in the research data landscape were equipped to tackle research data management.

A number of Workshops were held by the partners, in London, Vienna, Helsinki, Santiago in Chile and again in London.¹⁸ The purpose of the Workshops was to engage with stakeholders – researchers, research funders, library and IT support staff, publishers, research administrators, senior policy and decision makers – to identify key concerns in the RDM landscape which the project could address with tools and guidance.

Different stakeholders had different perceptions about what was important to them. For policy and decision makers, one of the most important issues was cost; they did not want to be asked to sign a blank

¹³ UCL Press: <http://www.ucl.ac.uk/ucl-press/publish>; last accessed 14 June 2017.

¹⁴ UCL Press: <http://www.ucl.ac.uk/ucl-press/browse-books/textbook-of-plastic-and-reconstructive-surgery/>; last accessed 14 June 2017.

¹⁵ UCL Press: <http://www.ucl.ac.uk/ucl-press/browse-books/key-concepts-in-public-archaeology>; last accessed 14 June 2017.

¹⁶ UCL: <http://www.ucl.ac.uk/teaching-learning/education-strategy>; last accessed 14 June 2017.

¹⁷ LEARN: <http://learn-rdm.eu>; last accessed 25 June 2017. The project received funding from the EU's Horizon 2020 Research and Innovation programme under grant agreement no. 654139.

¹⁸ LEARN: <http://learn-rdm.eu/en/events>; last accessed 25 June 2017.

cheque. LEARN itself was not an economic study, but the LEARN Toolkit did identify that costing was an elephant in the room: As 4C says, “*There is a sizeable canon of research into cost modelling for digital curation but the research is in many ways preliminary and there has been little uptake of the tools and methods that have been developed*”.¹⁹ LEARN helped moved the debate on by producing two best practice case studies from UCL and the University of Edinburgh – case studies 14 and 17 in the LEARN Toolkit.²⁰ No continental European or Latin American institution was able to provide comparable costs, a sign of the challenge that confronts the community.

6.1 LEARN Toolkit

The LEARN project sought to provide a number of tools and services which would help address the major issues identified in the Workshops. The resulting case studies were grouped together under 8 headings in the LEARN Toolkit:

- Policy and Leadership
- Advocacy
- Subject Approaches
- Open Data
- Research Data Infrastructure
- Costs
- Roles, Responsibilities and Skills
- Tool Development

The Toolkit also included a model RDM policy, which could be adapted by any institution or research funder and a LEARN Executive Briefing in 6 languages to inform decision makers what steps they should take.

6.2 20 Best Practice Recommendations on RDM

What were the main findings of the project? These are encapsulated in the 20 best practice recommendations which were identified in the Workshops (Figures 7-9).²¹



Figure 7: LEARN Workshops in action

¹⁹ 4C: <http://www.4cproject.eu/about-us/>; last accessed 9 February 2017.

²⁰ LEARN: <http://learn-rdm.eu/en/dissemination/>; last accessed 25 June 2017.

²¹ LEARN: <http://learn-rdm.eu/wp-content/uploads/20-RDM-Policy-Recommendations.pdf>; last accessed 25 June 2017.

The Recommendations concentrate on:

- Policy and Leadership
- Open Data
- Advocacy
- Costs
- Roles, Responsibilities and Skills

These themes are picked up in more detail in individual case studies, which follow the same taxonomy of classification.

The LEARN project found many issues in terms of Policy and Leadership. The Recommendations stress:

- Senior management can, and should, lead the way but it is equally important for a multidisciplinary range of stakeholders (e.g. scientific researchers, libraries, research funders, corporations, IT departments), including external experts such as legal advisers to be involved in a policy's formulation.
- A successful policy should make it easy, fast, interesting and rewarding for researchers to make data available, leading to lower administrative burdens.

6.3 Leadership and Policy

Leadership is an important theme and this was taken up in the first section of the LEARN Toolkit with 4 case studies on the subject and in the Executive Briefing. In terms of Policy and Leadership, the original LERU Roadmap advocated that 'Every LERU member should develop and promulgate an institutional data policy'.²² The LEARN Toolkit provides the tools to do this, with a model RDM policy developed by the University of Vienna and accompanying guidance. Additionally, the case studies support the call for policy leadership and alignment. Case Study 1 from the Wellcome Trust argues that there is broad agreement on policy amongst research funders on the importance of RDM, whilst identifying key challenges which remain.



Figure 8: LEARN Toolkit being disseminated in the Catalan region

The Executive Briefing is designed for senior decision makers, to support them in delivering sound solutions.²³ It is very clear about the challenge: Research Data is the new currency of the digital age, but there is a serious gap in the level of preparation in research performing organisations. The LEARN model RDM policy is designed to fill that gap, and it can be adapted by individual institutions. The template was developed following detailed study of 20 European RDM policies – 11 from the UK, 4 from Germany,

²² See Achard et al. (2013), paragraph 22.

²³ LEARN: <http://learn-rdm.eu/wp-content/uploads/LEARN-Executive-Briefing-v2-English-1.pdf>; last accessed 25 June 2017.

1 from the Netherlands and 4 from Finland. The Briefing also stresses that research data should be FAIR – Findable, Accessible, Interoperable, Re-usable. Research Data Management Plans are essential and form the basis for sound stewardship. All researchers, young and old, need access to training to equip them with the knowledge and skills they need. There are risks in not taking RDM seriously, for example researchers may lose funding by not complying with research funder requirements.



Figure 9: LEARN Workshop in Santiago, Chile

6.4 LEARN – Measuring Success

Two further deliverables from the LEARN project provide assistance to research performing organisations and research funders who wish to address the gap in provision for RDM which was first identified by the LERU Roadmap. A self-assessment questionnaire allows organisations to test their readiness for RDM.²⁴ There are 13 questions, and answers are graded with a traffic light system – Red, Amber, Green – depending on the level of preparation shown in each answer. The questionnaire is iterative and can be taken several times over a period of weeks, months or even years. Comparison of the scores over such a period will reveal progress, or otherwise, in embracing core RDM activities at institutional level.

A second tool is a set of Key Performance Indicators,²⁵ which allow an institution to measure their attainment in RDM activity. There are 27 KPIs, broken down into two sections – 8 for Preparation and 19 for Implementation. Within these two sections, the KPIs are grouped together in themes which correspond to the themes in the LEARN Toolkit.

Table 4 gives four examples of KPIs from the LEARN project, two on Preparation and two on Implementation. They are each related to the relevant theme of the LEARN Toolkit, to enable users more easily to address relevant aspects of RDM activity. Measures are suggested for measuring performance against the KPI – the measure might have a numerical value, or might simply consist of a Yes/No answer.

²⁴ Available at <http://learn-rdm.eu/en/dissemination>; last accessed 26 June 2017.

²⁵ See note 20.

The rationale for the measure is given in the final column. Where best practice already exists, this is referenced in this column. The KPIs are ultimately based on the Model LEARN RDM policy and the expected values defined in the KPI Table can be taken as a good indication that a suitable implementation of the RDM policy has been achieved.

Table 4: Exemplar KPIs from LEARN

Number	KPI	LEARN Toolkit Theme	Measurement	Expected Ongoing Value	Expected Final Value	Rationale for Measure
P1.1	Alignment with the LEARN RDM Model	Model RDM policy	Review of items in Policy which are included in the LEARN model	50%	90%	To avoid multiplicity of policy models, LEARN suggests a comparison with the LEARN model
P7	Training sessions on RDM	Advocacy; Roles, Responsibilities and Skills	Number of sessions developed in a year	Training sessions on demand	Regular scheduled sessions addressed to all the community	Any research performing institution should train its staff, researchers and students in RDM best practices
I1.1	Review of the policy	Policy and Leadership, Tool Development	Number of reviews in a year		1	A yearly review is advised as best practice to monitor the policy. This does not mean an update of the policy
I8	Amount of research income dedicated to RDM activities	Costs	Percentage of research income dedicated to RDM. The costs should include infrastructure (I8.1), staff (I8.2) and activities (I8.3)		>5%	Recommendation of High Level Expert Group's Report on the European Open Science Cloud

6.5 Open Data

LEARN is not in itself a study of Open Data, but rather of the broader landscape of research data management. Nonetheless, Open Data is treated in some detail in the LEARN Toolkit. Case Study 11, by Professor Geoffrey Boulton, makes a persuasive case for Why Open Data?²⁶

Figure 10 shows the Open Data Iceberg, which Professor Boulton used to great effect in the first LEARN Workshop in London. Comparing the challenge of Open Data to an iceberg, the main challenges are not above the waterline, but below. Technology is not the main challenge, but rather processes, organisations and people. Perhaps the biggest challenge lies with people, with three imperatives:

- Skills challenge
- Incentives challenge
- Mindset challenge

How are these challenges to be addressed? Case Study 18 in the LEARN Toolkit shows how this can be tackled.²⁷ LERU (League of European Research Universities) held a Research Data Workshop for early

²⁶ LEARN: Toolkit of Best Practice for Research Data Management. Chapter 11: G. Boulton: Why Open Data? at <http://learn-rdm.eu/en/learn-toolkit-download-individual-sections/>.

²⁷ LEARN: Toolkit of Best Practice for Research Data Management. Chapter 18: P. Ayris and I. Labastida: Training Early Career Researchers' at <http://learn-rdm.eu/en/learn-toolkit-download-individual-sections/>.

career researchers amongst the LERU membership in Leiden in Summer 2016. This was a taster for future collaborative activity across the LERU network. The Programme for the Summer School had as its ambition the creation of a ‘new generation of data scientists’. Each of the 21 LERU member universities was invited to send one or more members of their doctoral programme to attend the week, the intention being that having received training in Leiden they could then return to their organisations and cascade that knowledge around local doctoral candidates. 38 doctoral students attended the event from 21 LERU universities and associated hospitals.

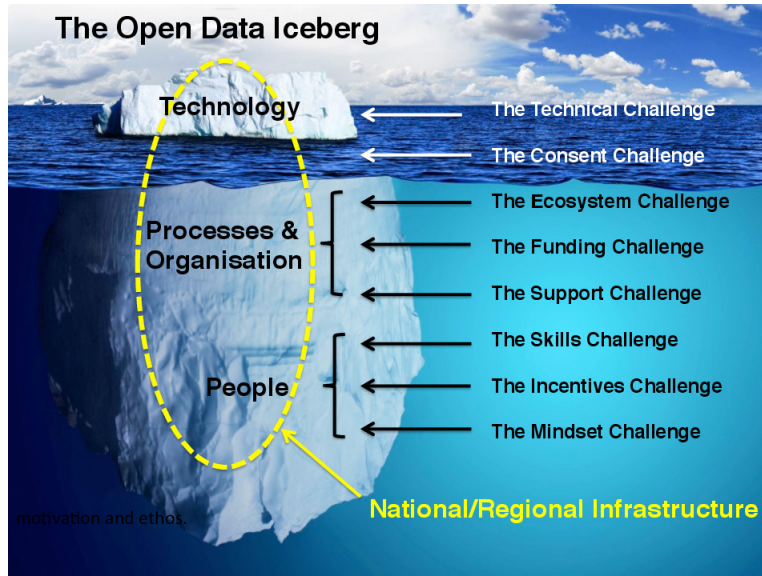


Figure 10: the Open Data Iceberg

The Summer School highlighted a number of issues, which seem likely to form the core of RDM training activity in future rounds. Some of the more prominent themes were:

- The importance of research data being FAIR (Findable, Accessible, Interoperable and Re-Usable)
- The importance of data management plans in providing a framework for the creation, storage and sharing of research data
- Licensing issues and an explanation of the meaning of the Creative Commons suite of licences and its use in research data
- Big Science is Open Science
- The future infrastructure for Open Science

As Professor Boulton emphasised in his Case Study, “Nearly two decades ago, Tim Berners-Lee proposed that datasets that relate to the same or related phenomena could be semantically linked in ways that integrate different perspectives, and thereby offer much deeper understanding than merely using the web as a means of retrieving documents”. Tackling the challenges to greater openness, Professor Boulton concluded, “It has great potential not only to enhance scientific understanding, but also the way that science is able to engage with the wider public in a more truly open science”.

6.6 LEARN: Contribution to Open Science

The [LERU Roadmap for Research Data](#) identified a significant gap in the demands of RDM and the ability of research-intensive universities to tackle the challenges which RDM presents. The objective behind LEARN

was indeed to meet those challenges and to provide tools and services which any research organisation anywhere in the world could adopt. Through the Toolkit of best practice and other LEARN tools, stakeholders in the RDM landscape have the means to prepare for the data deluge which faces them. As Professor Boulton underlined in his Case Study, *'In 2003, the human genome was sequenced for the first time. It had taken 10 years and cost \$4 billion. It now takes 3 days and costs \$1,000'*. Whilst not itself simply an Open Data project, the findings of the LERU Doctoral Summer School point to an interesting direction of travel. Many of the key issues identified by the participants revolve around Open Data. For researchers at the start of their career, Open Data clearly was the path that many of them wished to tread.

7 E-Infrastructures, especially the European Open Science Cloud

7.1 High Level Expert Group Report

The EU High Level Expert Group issued its Report on the European Open Science Cloud (Ayrís et al., 2016) in July 2016. Dr Ayrís was a member of this grouping as a University Librarian and former President of LIBER (Association of European Research Libraries). The Report considered a number of issues:

- Infrastructures
- Skills development
- Reward and Recognition
- Roles and Responsibilities
- Governance & Standards
- Funding Opportunities

The Report made a number of headline recommendations. In terms of infrastructure, it recommended that the nascent Cloud build on existing provision. It was not that new infrastructures were needed, so much as that existing infrastructures need to be more joined up and collaborative. Rules of Engagement need to be drawn up to ensure that it is clear how users can contribute to the cloud of data in the Open Science Cloud. All such data should be FAIR – Findable, Accessible, Interoperable and Re-usable. The European Cloud should not be seen as an isolated phenomenon; rather it should consider making links with other Clouds around the world to develop an interlinked global Cloud. Finally, research data scientists should themselves be considered part of the research data management infrastructure. The Report identified the need for half a million core data scientists in Europe. It also stipulated that research performing organisations should spend 5% of their total research spend on data stewardship.

7.2 How can the vision of the European Open Science Cloud be implemented?

How will the European Open Science Cloud be taken forward? Figure 11 shows how the European Commission intends to do this.

It is planned to issue an EOSC Declaration in the autumn of 2017²⁸. Institutions and organisations will be invited to sign up to its principles. In current drafting, the Declaration concerns itself with three major themes:

- Data Culture and FAIR data
- Research Data Services and Architecture
- Governance and Funding

For the EOSC to be delivered, there needs to be a change in culture amongst all members of the RDM community. This is what the theme Data Culture and FAIR data is designed to deliver. All research data

²⁸ Available at https://ec.europa.eu/research/openscience/pdf/eosc_declaration.pdf; last accessed 10 February 2018.

should be open by default; there is a need for education and skills development amongst researchers to equip them with the knowledge to manage their data outputs; all research data should be FAIR (Findable, Accessible, Interoperable, Reusable); researchers need to prepare data management plans; and the EOSC needs to engage with researchers to encourage them to make their research data assets available to the network.

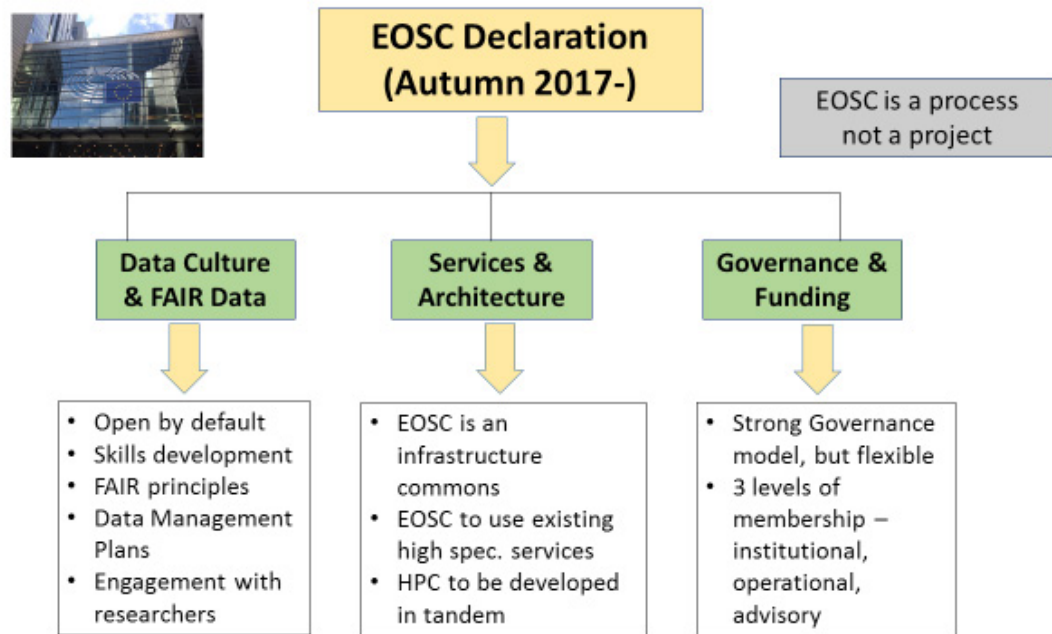


Figure 11: Implementing the European Open Science Cloud

The second theme, Services and Architecture, paints a picture of the EOSC as a data commons; it will use existing high-level data assets and structures where that is sensible; and High Performance Computing needs to continue to be developed alongside the EOSC, with relevant cross-overs.

The final theme looks at Governance and Funding. The EOSC needs to be managed, but in a way which encourages participation. The differing levels of membership being proposed – Institutional, Operational and Advisory – should ensure community participation as the EOSC develops.

7.3 Is a European Open Science Cloud enough?

Research is international in scope, and a European Cloud itself will not suffice to support the international collaborations which underpin research. To give just one example, UCL was awarded \$63 million from the Wellcome Trust and the Howard Hughes Medical Institute to deliver the Africa Health Research Institute (AHRI), a new organisation to fight the co-epidemic of TB and HIV in KwaZulu-Natal. While focussed on European research outputs, the EOSC needs in parallel to develop partnerships with global Cloud provision. Solutions to the challenges which face Society, such as disease, hunger, migration, global warming, need global solutions – they will not be solved by Europe alone. While the development of the EOSC is to be welcomed, it comes with the realisation that on its own it is not enough. The EOSC is a process, not a finite project. Its aim, to create a European data commons, is ambitious but has the potential to help change the way that global research is undertaken and disseminated.

8 Citizen Science

8.1 Citizen Science in essence

Another core element of Open Science is Citizen Science. With such an element, Open Science can contribute with a direct return of investment to our society, both in terms of accelerating the gathering of new scientific data and in educating the general population in scientific practices. For example, Extreme Citizen Science, ExCiteS, is a bottom-up initiative at UCL that allows citizens to design and build new devices and start knowledge creation processes with a broad network of people including university experts.²⁹

There are several definitions associated with Citizen Science. We have chosen the one that appears in the EC Green paper on Citizen Science for Europe (Societize, 2013):

“Citizen Science refers to the general public engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort or surrounding knowledge or with their tools and resources”

It is worth mentioning here the words of Professor Ian Chubb, former Chief Scientist of Australia, who illustrated very well how science should be open to all citizens: *“Science isn’t just something scientists do. It is something in which every single one of us has a stake”* (BioBlitz Australia, 2015).

To better shape the roles of libraries in Citizen Science, we should consider certain perspectives and expected outcomes.

On the perspectives side, we should look at Citizen Science from the scientific, education and engagement and event management perspectives. The scientific perspective questions what the contribution of citizens to science is, when we have it as an element of various scientific processes. The education and engagement outlook will reveal the contribution of Citizen Science to the education of the general population and the level of public engagement in scientific activities. The event management outlook considers what it takes practically to manage Citizen Science projects.

On the expected outcomes side, we could establish what scientific outcome we should expect from projects that include Citizen Science elements. We should not forget the scope of science, which is the study of nature and its properties (Bennett, 1968), where the social sciences and humanities are part of this. On the contrary, Citizen Science should provide extra resources for us, to accelerate and advance our studies. Furthermore, what should individuals expect when becoming part of Citizen Science projects? What does the community gain through supporting such projects? And last (not least), what is in it for organizations?

Having in mind the aforementioned perspectives and expected outcomes, let us have a brief look at Citizen Science components, from an executive point of view (See, e.g., Bonney et al., 2009). Of course, this is a general overview. Each component can generate roles for libraries, in various degrees of intensity:

- First of all, determine a research idea suitable for being developed with the support of lay citizens.
- Form a team. Ideally: a scientist, an educator, a librarian and an evaluator.
- Develop, test, and refine protocols, data forms, educational support materials and do not forget about a marketing and communication package.
- Recruit citizens and include them in a programme which will engage and retain their interest.
- Train citizens and keep records of their training activities/certificates.
- Event development. Citizen Science events can be on-site events, or online events; they can include base camps and many other forms of participation. There are roles for libraries in these activities. For example, making a bibliography of available good practices and checklists, making scientific literature available to participants, presenting the importance of Open Access and promoting your Institutional repository or your collections and services to all participants. And this list can continue.
- Build FAIR Data: accept, edit, make it FAIR and disclose it for sharing and reuse.
- During the research stage of analysing and interpreting data, inform citizens about the research methods

²⁹ LERU: <https://www.leru.org/files/Citizen-Science-at-Universities-Trends-Guidelines-and-Recommendations-Full-paper.pdf>; last accessed 18 December 2017.

that are involved and the use of their data. Lay citizens will keep their enthusiasm when informed about how their contribution is being taken further in the research process.

- Disseminate results. Use both academic and pop-science standards. Remember that lay citizens are not scientists. They cannot easily follow or even access scholarly communication outputs. They are much more used to reading a magazine-style article or to follow a video episode on topics that are close to their interests. It is worth mentioning that pop-science will help libraries and scientists to reach remote layers of the population that are not willing to play an active role in Citizen Science projects, but they still have enough interest to follow progress on specific topics. They are the supporters of science that may eventually emerge into more active players on science playing field.
- Measure outcomes while taking into consideration the perspectives that we mentioned above: scientific, education and engagement, and event management.
- After-event actions will maximize the achievements of the project. The enthusiasm that is built during the project has to be collected and maintained after its conclusion. It should be a great occasion for your institution to build stronger relationships with individuals and organisations that contributed during the research project. By reporting the achievements to other organisations and authorities, it will help to create an advocacy programme for science in general and/or for specific topics in particular.

In our quest for library roles in Citizen Science projects, we decided to run a survey and over 180 invitations were sent to librarians, researchers, project administrators and authors of Citizen Science studies. This survey remains open and your answers will help us further to shape these roles. Its aim is twofold:

- To picture the current involvement of libraries in Citizen Science
- To receive ideas about suitable roles for libraries in Citizen Science initiatives

At the date of writing this article, we have received only 10 answers. The low response rate perhaps says something about the current lack of engagement of libraries in Citizen Science initiatives. You are kindly invited to make your contribution at <http://www.knowledge.services/citizenscience>.

In addition to this survey, we have held a small number of interviews with leading librarians and community communication managers from institutions that are currently engaged in Citizen Science projects. Some of our respondents have in turn a contribution in proposing a role for libraries in Citizen Science projects (Bunge, 2017).

Considering the general framework of preparing any institution (including libraries) to become part of the transition to Open Science, we see 4 main pillars that will help manage the change:

- Build the right skills in your staff.
- Develop or adopt a toolkit that will help you in the practical aspects of managing the transition.
- Make a good plan and act with discipline to achieve your goals.
- Develop and act with a sense of leadership; make sure you lead the change and not just follow external changes.

8.2 Roles for libraries in Citizen Science projects

Taking into consideration the aforementioned pillars, our findings from various studies, our survey and interviews, here are suggested roles for libraries that we see when their institutions or they themselves are running Citizen Science projects.

First, build skills for engaging in Citizen Science projects. Consider introducing a training programme and even courses for undergraduates that explain the essentials of such projects, what opportunities lie ahead, what the pros and cons and the practicalities of implementation are.

Support, be part of and adopt a toolkit for developing Citizen Science projects. This series of tools will help you to develop your organisation as you take on such responsibilities. Such a toolkit should also include evaluation mechanisms that will help you to correct and improve your offering.

Build a collection of protocols, data forms, educational materials and all sorts of content that are used and are generated during Citizen Science projects. Such materials should follow the same FAIR principles as in data management.

Contribute to FAIR data and develop collections of such data. Citizen Science projects generate data and libraries' support in this matter is much needed.

Offer your infrastructure for such projects: IT services, servers, your institutional repository, spaces for meetings and conferences. Libraries can provide collection points for data and run workshops for uploading data.

Libraries should contribute to the evaluation process of the project, such as the FAIR attributes of data, the evaluation of the educational outcomes of the project and as a partner for other evaluation tasks that are shared within their research organisation.

Another role for libraries is to communicate information about collections related to the theme of the project and those that become an outcome of it. In this respect, libraries should support both scholarly and pop science communication.

In addition, Citizen Science projects open up new opportunities for libraries and subsequent roles that we recommend to be adopted:

- Participate in the recruitment and retention processes for staff/volunteers.
- Assist volunteers to register with Citizen Science projects.
- Participate in marketing activities.
- Promote a positive attitude towards Citizen Science.

8.3 Citizen Science is a key part of European initiatives

As part of its 2018-2022 Strategy, LIBER wants to increase the role of libraries in supporting Citizen Science. It proposes to do this by:

- Ensuring that Citizen Science enthusiasts are informed about library support for this field.
- Making an overview of Citizen Science actions in Europe available to LIBER members.
- Organising a Citizen Science workshop where members can discuss the most valuable actions.

The European Council recommends (Societize, 2013):

- Promote the creation of appropriate tools as well as standards for interoperability, metadata, citations, anonymization and accessibility.
- Promote the design and definition of sustainability models for Citizen Science projects with long-term commitment for infrastructures and data repositories.
- Reform researcher evaluation and reputation systems, and the definition of incentives for interaction with citizens, such as recognition in appraisal and tenure.

LERU (League of European Research Universities) includes in its 20th Advice Paper (Grey et al., 2016):

- (LERU) Recognises Citizen Science as an evolving set of research methods, as well as its societal and educational benefits.
- (LERU) Recommends creating a single point of contact for Citizen Science within the institution, to advise scientists and ensure liaison with national and regional Citizen Science initiatives.

9 Engagement in Open Science approaches?

9.1 UCL's Open Science Policy Platform

Open Science is an emerging field and represents a real challenge in how universities and research performing organisations can interact with it. One possible model appears in Figure 12. This represents a new organisational structure in one world-leading research performing organisation – UCL (University College London), and this structure promotes the leadership role of the Library.

UCL (University College London) has established an Open Science Policy Platform. It is chaired by the Pro-Vice-Provost (UCL Library Services) in the Office of the Vice-Provost (Research). The aim of the Platform is to look at the institutional strategy, UCL 2034, and to identify areas which would benefit from alignment with the vision for Open Science. In terms of implementation, the Platform has identified 6 main areas for initial action and implementation:

- Open Access and OA Publishing
- Bibliometrics
- Research Data Management
- Recognition, Promotion and Reward Structures
- Open Education
- Citizen Science

In each of these areas, the Pro-Vice-Provost works with existing committee structures in UCL to promote Open approaches and to develop the relevant e-infrastructures to deliver Open activities.

9.2 The elements of Open Science Publishing Platform activity

For OA publishing, the Open Science Policy Platform works with the UCL Press Board to deliver the UK's first fully Open Access University Press. UCL Press is a constituent department of the Library. The University Bibliometrics Working Group is working on a University Bibliometrics policy – one which acknowledges DORA (the San Francisco Declaration on Research Assessment)³⁰ and establishes new norms for evaluation and metrics.³¹ The Bibliometrics Working Group is also led by the Library. Research Data Management is a major focus for UCL and the EU-funded LEARN project has provided a wealth of templates, metrics and case studies to develop an institutional offering. LEARN was based in UCL Library Services. In the new UCL academic reward and promotion structures, the Library successfully lobbied for Open approaches to be embedded as core in the promotions criteria³².

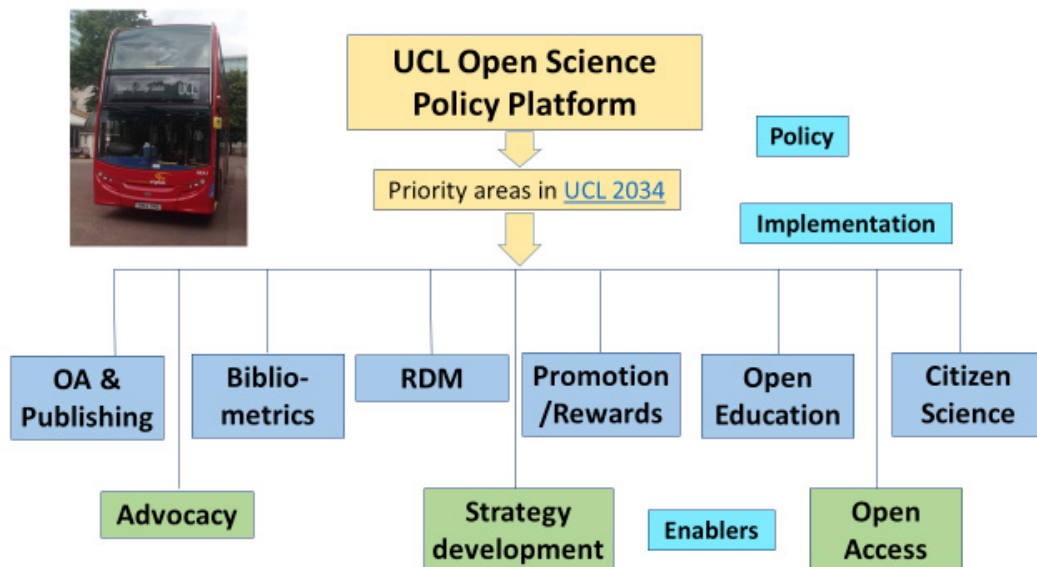


Figure 12: UCL Open Science Policy Platform

³⁰ San Francisco Declaration: <http://www.ascb.org/dora/>; last accessed 31 July 2017.

³¹ See Wilsdon, J. (2016, July 29), which has informed UCL thinking in the area.

³² Available at <https://www.ucl.ac.uk/human-resources/policies-advice/academic-career-framework-and-promotions-processes/>; last accessed 10 February 2018.

The new UCL Promotions policy came into effect on August 1, 2017. Open Education is also a new focus for UCL activity. In 2017/18, UCL Press is publishing 10 Open Access textbooks to launch its publishing stream in this area; and UCL will also scope the creation of an Open Education repository, to match the research repository for publications UCL Discovery. This too will be led by the Library. Citizen Science is a theme with several offerings in UCL, and in developments such as Transcribing Bentham³³ the Library is making an important contribution.

All this Open Science activity is supported by 3 enabling actions performed by the Library – advocacy, relevant strategy development, and Open Access activity as the default. In this way, UCL hopes that it can prepare itself for the challenges and benefits which Open Science brings.

10 Conclusions

What conclusions can be drawn from this overview of approaches to Open Science? The paper has looked at the current challenges facing Science and attempted to define the components of Open Science. It has then looked at some of these areas in detail: Open Access and Open Access publishing, Research Data Management, E-Infrastructures especially the European Open Science Cloud, and Citizen Science, all supported by possible approaches to engagement in Open Science. The lessons learned are drawn from European case studies and the EC-funded LEARN project on Research Data Management.

What are the challenges for libraries that can be identified in this analysis of Open Science? The suggestion of this paper is that libraries need to engage in a 4-step test to measure their engagement in Open Science (Figure 13):

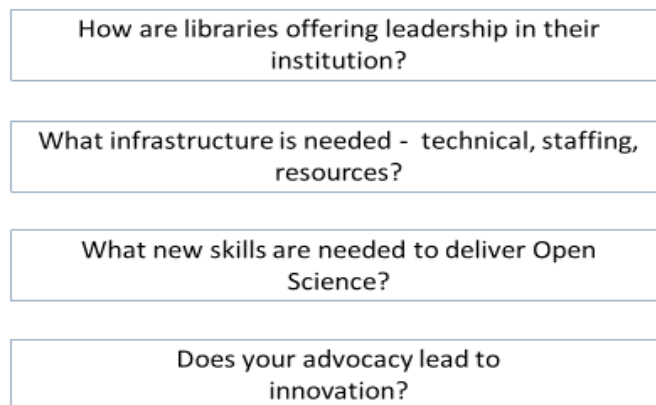


Figure 13: 4-Step Test for libraries to test their engagement in Open Science

Libraries can offer leadership, as the example of UCL and their Open Science Policy Platform proves. Infrastructure is important – be it technical infrastructure like the European Open Science Cloud or administrative and publishing infrastructure to deliver Open Access approaches. New skills are crucial and, as the High Level Expert Group on the EOSC recommended, a pan-European emphasis on training is needed to deliver the skills base to support Open Science activities such as Research Data Management. Finally, does a library’s advocacy lead to innovation – in any of the areas which are components of Open Science?

Open Science represents new ways for society to engage with science. It is revolutionary in its ambition and libraries have a core role to play in supporting its success.

³³ Transcribe Bentham: <http://blogs.ucl.ac.uk/transcribe-bentham/>; last accessed 31 July 2017.

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