European Commission

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

Written by The Working Group on Education and Skills under Open Science
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Research and Innovation

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EUROPEAN COMMISSION

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

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Directorate-General for Research and Innovation
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EXECUTIVE SUMMARY

Open Science is transformative to the research landscape, allowing research to be carried out with a high degree of transparency, collegiality, and research integrity. For Open Science to become a reality, researchers need appropriate discipline-dependent skills training and professional development at all stages of their research careers. To facilitate this, the Steering Group on Human Resources and Mobility (SGHRM) Working Group (WG) on 'Education & Skills'[1] worked with a specific mandate to propose recommendations to ensure that researchers in Europe have appropriate skills and competences to practice Open Science[2]. The overarching goal is to ensure that OS skills become an integral and streamlined component of the standard education, training and career development paths of researchers, and if possible even at earlier career stages, in schools and universities.

The Working Group conducted a survey between March and May 2017 to assess the current situation. A total of 1,277 answers were received by researchers across Europe, of which nearly 50% were doctoral candidates (R1). The remaining 50% were distributed across career stages, from the postdoctoral to the very senior research career levels. A majority of researchers are unaware of the concept of Open Science. What is most known is open access publishing, and there is a very high interest in open access data management practices. Researchers indicate that training opportunities for open access and open data are not yet widely offered. 3 out of 4 researchers indicate that they have not yet participated in any open access or open data course but would like to. Although an even higher proportion of researchers deem data management relevant for their research, there is insufficient data archiving support and infrastructures at the institutional level. Given that research data production, documentation and archiving is essential for a majority of researchers, it is crucial that they are aware of, trained and supported with the best technologies to enable and enhance professional conduct.

The skills necessary for Open Science are identified and include; open access publishing; data management and open data; enabling professional research conduct; citizen science. An overview of the current Open Science skills provision landscape is given. The need to engage researchers at all levels in Open Science is discussed and a European Skills and Qualifications Matrix for Open Science is proposed. The importance of embedding Open Science in ERA policy is treated and the specific cases of the Innovative Doctoral Training Principles and the European Framework for Research Careers are presented.

The following are key recommendations to enhance open science skills in the research community:

- **Open Science policy**; including the analysis of ERA policy through the lens of Open Science, and making Open Science skills an integral part of the next framework programme (FP9) with dedicated funding.
- **Guidelines to implement Open Science**, which include a revision of the major European Guidelines and Frameworks concerning researchers' skills and career development to include Open Science, i.e. the European Framework for Research Careers, the Human Resources Strategy for Researchers (HRS4R),[3] and the Innovative Doctoral Training Principles (IDTP).[4] This also includes the development of FAIR institutional guidelines, in particular for Open Access publications and Open Data.
- **Raising awareness of Open Science** policy initiatives, institutional and funding agency guidelines, as well as the broader value of Open Science practices at the personal, professional and societal levels.
- **Training Researchers for Open Science** ensuring career stage appropriate accredited and modularised Open Science skills training and professional development (covering R1-R4 researchers) regarding open access publishing, open data and data management, professional research conduct and broader citizen science skills.
- **Providing Support for Open Science**, including infrastructure, technical, legal, professional and implementational support from institutions.
- Career development for Open Science, such that Open Science activities are recognised by funders as part of grant evaluation criteria, are accounted for in the recruitment and progression of researchers, and are recognised and rewarded (see also recommendations of the Rewards Working Group under SGHRM) with the highest degree of visibility (skills visibility and transparency).[5]

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1 See appendix 1 for details.

2 in parallel another Working Group on Incentives & Rewards, has focused on Recognition and Rewards for researchers practising Open Science.

3 https://euraxess.ec.europa.eu/jobs/hrs4r

4 https://euraxess.ec.europa.eu/belgium/jobs-funding/doctoral-training-principles

5 http://ec.europa.eu/social/main.jsp?catId=1223

1. INTRODUCTION

"*researchers at all career stages*[6] *should seek to continually improve themselves by regularly updating and expanding their skills and competencies. this may be achieved by a variety of means including, but not restricted to, formal training, workshops, conferences and e-learning*".

– Continuing Professional Development - European Charter for Researchers[7]

When all researchers are aware of Open Science, and are trained, supported and guided at all career stages to practice Open Science, the potential is there to fundamentally change the way research is performed and disseminated, fostering a scientific ecosystem in which research gains increased visibility, is shared more efficiently, and is performed with enhanced research integrity. It can create unprecedented connections between researchers and the general public, allowing for a vibrant citizen science movement, poised to have transformative effects on how research is executed.

Open Science represents an approach to research that is collaborative, transparent, and accessible.[8] A wide range of activities comes under the umbrella of Open Science, including Open Access publishing, Open Data, Open Notebook, Open Peer Review, and Open Education. Also included is citizen science, where non-specialists engage directly in research. Open Science goes hand-in-hand with research integrity, and requires legal and ethical awareness on the part of researchers. A driver for Open Science is the improvement of the transparency and validity of research as well as public ownership of science, particularly that which is publicly-funded.

The main driving force for the establishment of the Open Science WG on Education & Skills is the general shortage of appropriate skills training and guidance for Open Science in the researcher community. This report focuses not only on First Stage Researchers (R1 – up to the point of PhD) and Recognised Researchers (R2 – PhD holders or equivalent who are not yet fully independent), but also Established Researchers (R3 – researchers who have developed a level of independence) and Leading Researchers (R4 - researchers leading their research area and field).[9]

The skills needed for Open Science cover a broad span from data management to legal aspects, and include also more technical skills, such as data stewardship, data protection, scholarly communication and dissemination (including creating metadata) as shown in Figure 1.1.

It is critical to ensure that researchers at all levels have access to professional development and the appropriate skills to fully engage with Open Science. This professional development must be tailored for all four research stages (R1 to R4), whereby middle and senior career researchers need to take leadership and act as catalysts to change the culture of doing research. This change in mind-set and culture, backed up with modernising the higher education sector,[10] in turn, must be supported by universities/research institutions, funding agencies and underpinned by European, regional and national policy.

Open Science skills training and development is also important, because broad-spectrum implementation of Open Science skills will have a major impact on research integrity, enabling researchers to avoid plagiarism, data manipulation, and data falsification. We will focus in this report particularly on Open Access and Open Data and also provide an additional emphasis on citizen science and the need for stimulating interaction between researchers and non-academic stakeholders and the general public.

6 https://euraxess.ec.europa.eu/europe/career-development/training-researchers/research-profiles-descriptors

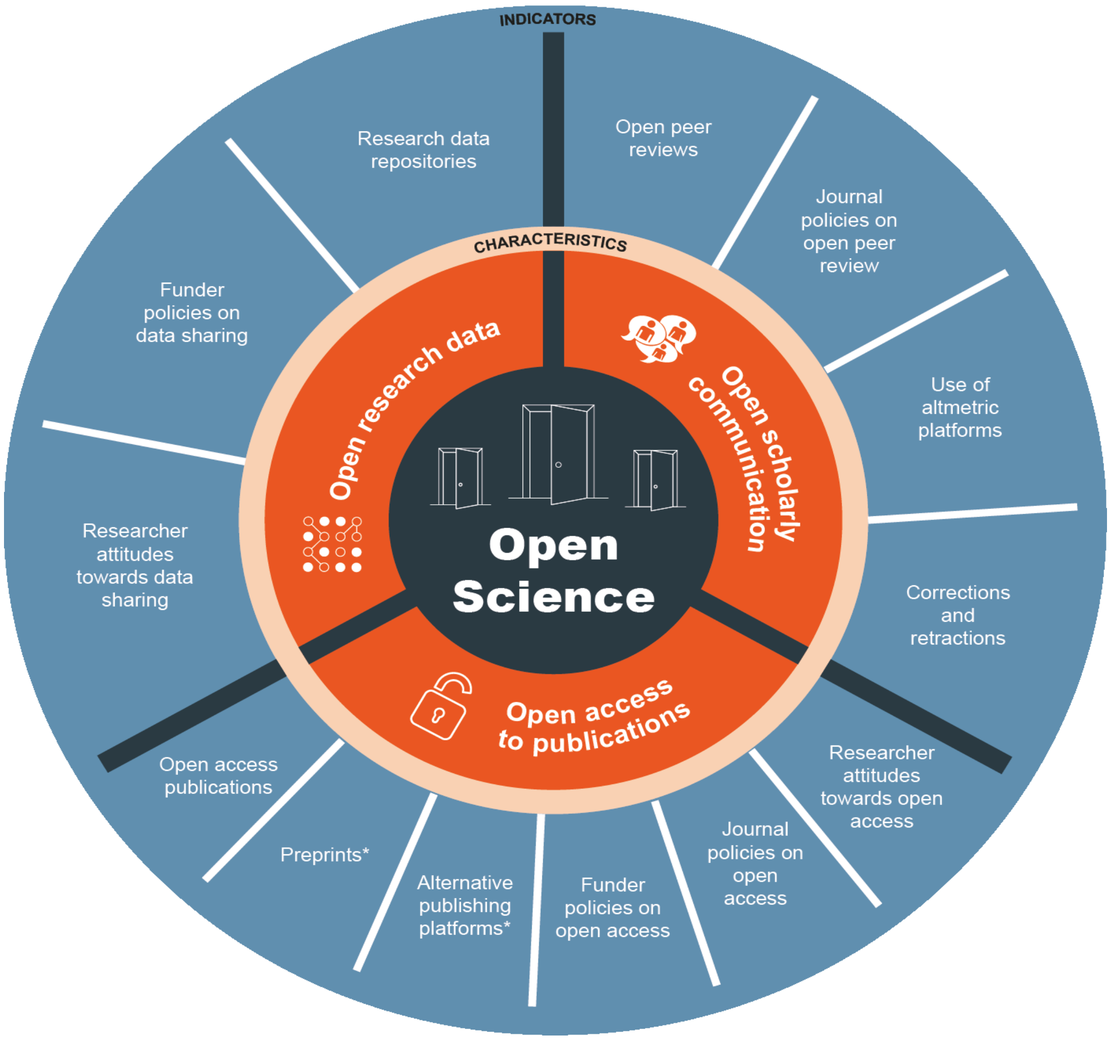
7 https://euraxess.ec.europa.eu/jobs/charter/european-charter

8 http://ec.europa.eu/research/openscience/index.cfm?pg=home&section=monitor

9 https://euraxess.ec.europa.eu/europe/career-development/training-researchers/research-profiles-descriptors

10 https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-1062784_en

Figure 1.1: Open Science "Wheel", describing key Open Science characteristics and indicators. Created by the Open Science Monitor.[11]



It is important to be aware that efforts to engage researchers with Open Science are not something new. As will be outlined in this report, there is a lot of current activity in the area of Open Science skills training, and many elements of commonality and complementarity exist across the expertise provided. Therefore, it is necessary to present the 'as is' and the 'to be' of the European Open Science skills landscape. In developing the latter, we will bear in mind the exhortation of the Bratislava Declaration of Young Researchers,[12] as follows,

" We call on the EC and Member States to incorporate research and scientific skills into high-school education through radical reform of curricula and methods of assessment: students must be given the opportunity to practise research and scientific thinking in schools – not just listen to teachers talk about it."

In this report, we will address the need to engage with and convince:

- **Researchers R1/R2** – of the need for these skills as part of their learning process as well as the need to link to recognition/rewards and the impact of acquiring and using OS skills.
- **Researchers R3/R4** – of the need to take leadership and ensure that their mentees acquire the skills as well as the need to demonstrate to them the positive effects of sharing data and information.

11 http://ec.europa.eu/research/openscience/index.cfm?pg=home&section=monitor

12 http://www.eu2016.sk/data/documents/bratislava-declaration-of-young-researchers-final.pdf

- **Funding agencies** – of the need to promote, reinforce, recognise and reward Open Science skills and to include these as eligible costs in their funding programmes. One could envisage a situation where funding agencies would collectively support regional and national courses.
- **Employers of researchers** – to incorporate Open Science skills as part of career development and also recognise and reward these skills in recruitment and career progression.

In doing so, we also acknowledge the need to be sensitive to independent learning styles and to different disciplines. Not all disciplines are data intensive or even collaborative and different disciplinary scholarly communication practices are established. For example, there is a perception that e-theses may not be made Open Access in certain disciplines due to the need for arts and humanities-based R1 and R2 researchers to produce monographs which are based on their theses for recruitment and promotion purposes.

The Working Group on Education & Skills mandate (see Appendix 2), approved by the Open Science Policy Platform (OSPP), was entrusted with the following tasks to recommend on aspects such as:

- Introduce Open Science education and training that is tailored to the four research career stages (R1 to R4).
- Include Open Science modules with credits in all European Doctoral Training Programmes (Doctoral level), by 2020.
- Revive the Doctorate in Europe discussion with the Steering Group on Human Resources and Mobility and link it closely to Open Science issues which will need to be incorporated.
- Link the Innovative Doctoral Training Principles to Open Science practices to encompass an open research environment.
- Explore together with the Open Science Policy Platform how training in Open Science practices could be addressed in early education (bachelor, master, high school) and propose concrete measures to team up with existing Commission policy initiatives on Education (associate DG EAC, they have the lead).
- Discuss and develop links between the European Skills agenda and contribution to its implementation supported by Open Science practices.

The expected results of the WG on Education & Skills are practical recommendations that can be adopted by policy makers at national, regional and European level and by funders, employers and all researchers. This report opens with the results of the pan-European survey on the perspectives of researchers on Open Science. The report then examines the various skills researchers need to successfully practise Open Science and how to encourage and engage researchers at all levels in Open Science. Existing policy initiatives from the ERA are then aligned with Open Science before the report closes with providing main policy recommendations and recommendations on how ERA policy will be embedded into the Open Science agenda. Finally, we note that even though the focus of the report is on skills for Open Science, the report goes far beyond this and references the whole spectrum of related issues, as without the necessary infrastructure, technical support and institutional mandates, it would be challenging for researchers to practice Open Science, even if the skills training is available.

2. OPEN SCIENCE FOR RESEARCHERS: PERSPECTIVES AND GOOD PRACTICES

2.1. Survey on Open Science and Career Development for Researchers

To provide a solid basis for recommendations, the working group developed[13] a pan-European survey which was aimed at researchers across Europe and beyond, and focused on their awareness of Open Science policies as well as the skills and facilities they need to practise Open Science.[14]

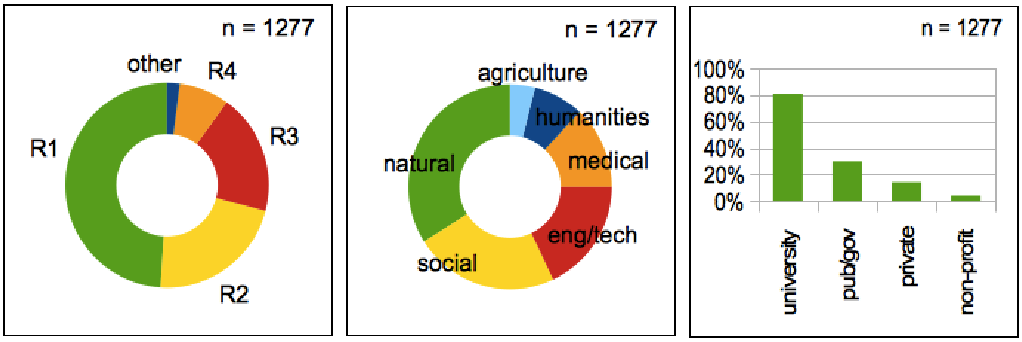
13 We are further grateful to several policy officers at the European Commission, members of Eurodoc, and other researchers who commented on and tested the survey before release.

14 https://ec.europa.eu/eusurvey/runner/OSCDSurvey2017

The survey drew on previous surveys on Open Science and career development for researchers.[15] The survey was put online using the EUSURVEY Tool, and was distributed widely amongst researchers via the European Council of Doctoral Candidates and Junior Researchers (Eurodoc), the European University Association (EUA), EURAXESS centres, and the European Commission. The survey was live from 20 March 2017 until 15 May 2017.

In total, 1,277 researchers answered the survey. This response rate is comparable to other global surveys for researchers.[16] Slightly more researchers identify as female than male.[17] The majority of researchers are 26-35, with a minority younger than 26 and the rest older than 36. Most respondents are First Stage Researchers (R1), followed by Recognised, Established and Leading Researchers (R2, R3, and R4).[18] Most respondents are from natural sciences, followed by social sciences, engineering and technology, medical and health sciences, humanities, and lastly agricultural sciences. While most are affiliated with a university, there are also researchers who are (co-)associated with public/governmental, private/non-governmental, and non-profit organisations. Most countries in Europe (and some beyond) are represented in the responses, although some are more represented than others. See Figure 2.1 for respondent affiliations.

Figure 2.1: Respondents per researcher type, discipline, and sector.



The survey consisted of many questions split into six categories for the framing of policy and researcher awareness of, training, practising, supporting, accessing, and rewarding Open Science. These categories can be viewed as sequential steps in the process of Open Science and involve policy makers, funders, research performing organisations, researchers, and the general public.

2.2. Framing Open Science

The survey indicates that many researchers today know something about Open Science, but their knowledge of different aspects of Open Science varies as shown in Figure 2.2. Three out of four researchers state that they know 'a lot' or 'some' about Open Access publishing. Most also know 'a lot' or 'some' about Open Source and Open Data. In contrast, just over half know 'little' or 'nothing' about Open Peer Review, while even more know 'little' or 'nothing' about Open Education, Citizen Science, and Open Notebook. Early-career researchers (R1 and R2) know less about Open Science practices than senior researchers (R3 and R4). Skills training on Open Science should take the awareness of researchers on the main policies and aspects of Open Science into account.

Good Practice on Awareness: The Open Access article "Do You Speak Open Science? Resources and Tips to Learn the Language" from Paola Masuzzo and Lennart Martens (2017) is a welcome introductory article to Open Science for unwitting researchers.[19]

15 We used and/or modified some questions from an Austrian survey on Open Data https://phaidra.univie.ac.at/view/o:409318, a survey on Open Access by the European University Association (EUA) https://eua.az1.qualtrics.com/SE/?SID=SV_088maB08sabUiTX, and a survey on career development by the Centre of Science and Technology Studies (CWTS) at Leiden University https://leidenuniv.eu.qualtrics.com/jfe/form/SV_bCyrlKSxU92LMMd.

16 See the recent (2017) survey on Open Data from Elsevier and Leiden University's CWTS: https://www.elsevier.com/__data/assets/pdf_file/0004/281920/Open-data-report.pdf.

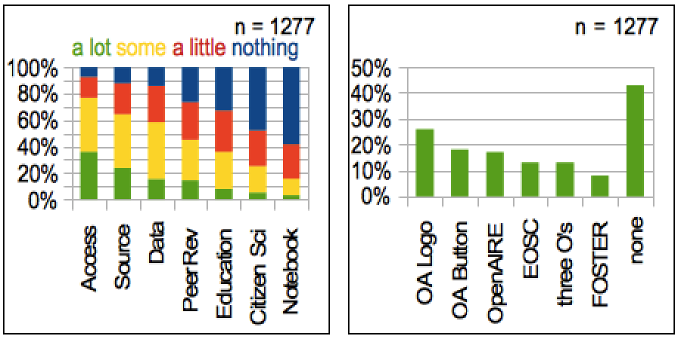
17 See the appendix for the survey questions and a general summary of the results (excluding the results for Q33-35 which were open questions).

18 Note that we included an 'other' category for researchers who felt that they did not fit into these categories. Also note that the survey questions usually allowed either a single answer or multiple answers. Answer percentages in the former always total 100% but can exceed 100% in the latter.

19 https://peerj.com/preprints/2689/

Researchers are, similarly, largely unaware of international Open Science initiatives as in Figure 2.2. Most are unaware of the FOSTER project,[20] Open Innovation,[21] Open Science,[22] Open to the World,[23] and the European Open Science Cloud (EOSC).[24] They are more aware of the OpenAire[25] project and the Open Access Button,[26] with the Open Access Logo being the most well-known. Additionally, both the Human Resources Strategy for Researchers (HRS4R)[27] and the Charter & Code for Researchers (C&C)[28] are quite unknown. Early-career researchers are less aware of Open Science policy initiatives than senior researchers.

Figure 2.2: Awareness of Open Science practices and initiatives.



Good Practice on Promotion: SPARC is a global coalition of academic and research libraries committed to making Open Science the default for research and education.[29] SPARC mainly promotes Open Access to publications, Open Data, and Open Education resources.

Zooming in on Open Access, we see from the survey that almost half of all researchers do not know if their institutions have guidelines for Open Access publishing as in Figure 2.3. The availability of formal institutional guidelines, or even informal institutional guidelines, for Open Access is low from the perspective of researchers, with under one third saying there are no guidelines at all. A similar picture emerges for guidelines from funding bodies as in Figure 2.3. A minority of researchers says that there are strict guidelines or suggested guidelines for publishing in Open Access from their funding. Almost one half say there are no guidelines, with under one third insisting there should be. More than one third simply does not know. Early-career researchers are more uncertain about the availability of guidelines than senior researchers. Such guidelines are essential in the skills training and support of all researchers.[30]

Good Practice on Guidelines: The University of Helsinki requires their researchers to self-archive academic publications in the university's Open Access repository HELDA.[31] The university provides more information on self-archiving and Open Access in an Open Access guide.[32]

20 https://www.fosteropenscience.eu/

21 https://ec.europa.eu/research/openinnovation/index.cfm

22 https://ec.europa.eu/research/openscience/index.cfm

23 https://ec.europa.eu/research/opentotheworld/index.cfm

24 https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud

25 https://www.openaire.eu/

26 https://openaccessbutton.org/

27 https://euraxess.ec.europa.eu/jobs/hrs4r

28 https://euraxess.ec.europa.eu/jobs/charter

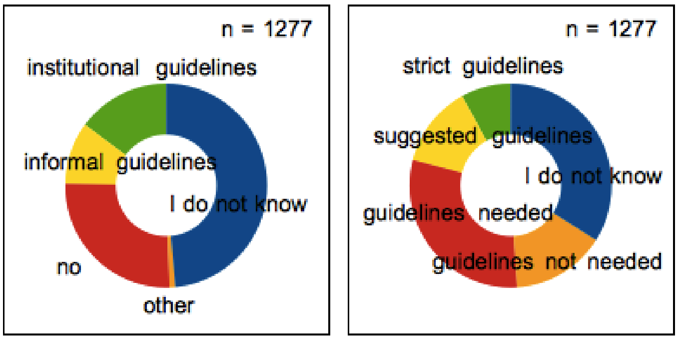
29 https://sparcopen.org/

30 Our survey results on the relatively low awareness of researchers of Open Science practices, policies and guidelines are comparable to results from the recent 2016/2017 institutional survey on Open Access by the European University Association (EUA).

31 https://helda.helsinki.fi/

32 http://libraryguides.helsinki.fi/oa/eng

Figure 2.3: Awareness of institutional and funding guidelines.



Good Practice on Policy: A consortium of major stakeholders in the Netherlands has launched a National Plan Open Science[33] and a website[34] to promote Open Science and realise concrete steps to make Open Science more accessible to researchers and the general public.

2.3. Professional Development for Open Science

Researchers perceive the opportunities for skills development better through actual practice than through training courses as shown in Figure 2.4. They more actively 'learn by doing' in the areas of collaboration and networking, research publishing and dissemination, teaching and supervision, research and data management, research integrity, and popularising science for the general public. Opportunities for learning by doing are lower for involving the general public in research, fundraising and investment pitching, and intellectual property and patenting.

There is a clear need either for more courses or more awareness of existing courses for researchers on Open Science at institutions as in Figure 2.4. One quarter of researchers are aware of courses on research and data management, teaching and supervising, intellectual property and patenting (IPR), research publishing and dissemination, and research integrity. Respondents are less aware of courses on popularising science for the general public, fundraising and investment pitching, involving the general public in research, and collaborating and networking. More opportunities via learning by doing than via courses apply generally for all researchers at all career stages.

Good Practice on Training: The FOSTER portal is an e-learning platform that brings together the best training resources on Open Science.[35] FOSTER offers broad training on all aspects of Open Science and offers specialisation by co-funding community-driven events.

Training opportunities specifically for Open Access and Open Data similarly do not seem to be in place from the perspective of researchers as in Figure 2.4. This is remarkable since Open Science has long been on the agenda and many institutions have skills courses on offer. Few researchers have actually followed courses on publishing and data management. This contrasts sharply with the majority who would like to follow skills courses. The absence of courses on data management is noteworthy as four out of five researchers deem data management relevant for their research.

Good Practice on Courses: Leiden University's Centre for Digital Scholarship actively promotes and supports Open Science and offers researchers specialised courses on Open Access and Open Data.[36] The two main courses focus on publishing in Open Access and research data management.

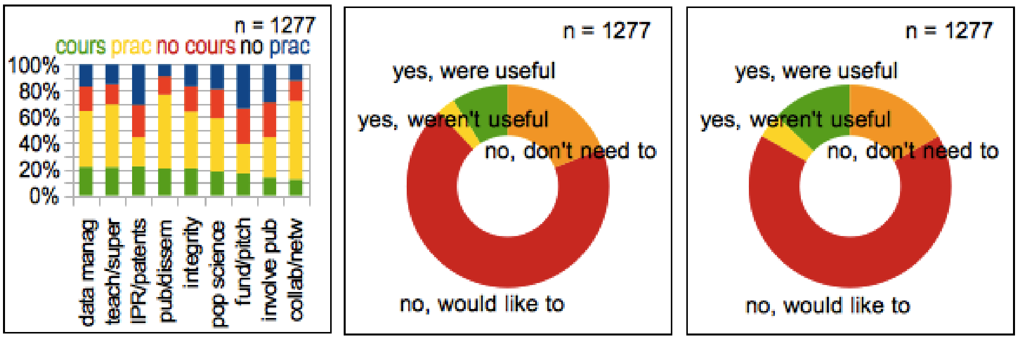
33 https://repository.tudelft.nl/islandora/object/uuid:9e9fa82e-06c1-4d0d-9e20-5620259a6c65?collection=research

34 https://www.openscience.nl/en

35 https://www.fosteropenscience.eu

36 https://www.library.universiteitleiden.nl/research-and-publishing/centre-for-digital-scholarship

Figure 2.4: Courses followed on Open Science, Open Access, and Open Data.



2.4. Supporting Open Science

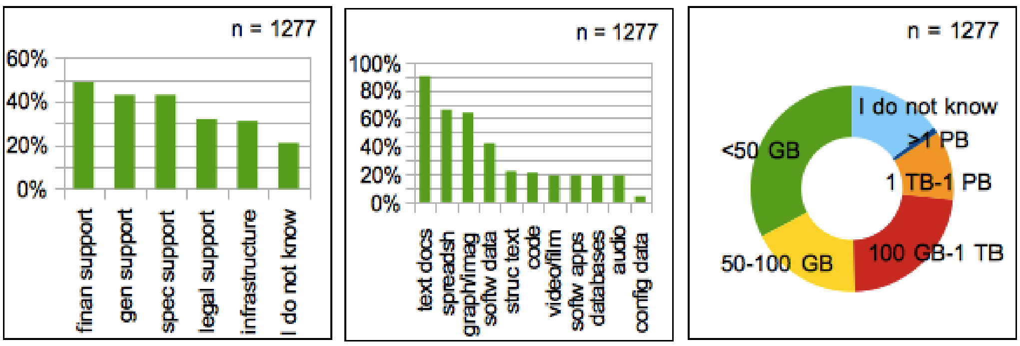
It is not enough to simply encourage and train researchers to do Open Science. Supporting Open Science by providing a digital and support infrastructure for researchers is crucial to maintaining momentum in initial Open Science advances. Support for Open Science is, however, generally lacking in institutions from the perspective of researchers as in Figure 2.5. They mainly miss or are unaware of financial support for publishing, specialist support for publishing and data management, and general support such as a help desk. To a lesser extent, they also lack legal support such as for Intellectual Property Rights (IPR) and the technical infrastructure to facilitate Open Science. Most researchers are aware of some form of support as only a fifth does not know what support is missing. Early-career researchers are less sure than senior researchers of what support is missing.

Good Practice on Infrastructure: The OpenAIRE project was set up to provide a technical infrastructure and support mechanism for the identification, deposition, access, and monitoring of results from FP7 and ERC projects.[37] It is assisted by both a European and national helpdesks.

To support researchers in creating data from their research, we need to know what types and how much digital content they create. Researchers mainly produce text documents, spreadsheets, graphics/images, and data (the latter from specialised software), as in Figure 2.5. Structured text, source code, videos/films, software applications, databases, audio files, and configuration data are also created to a much lesser extent. We also need to know how much digital content researchers create so they are provided with adequate digital storage space for their data. Most researchers need data storage up to 50 GB, between 50 and 100 GB, or 100 GB to 1 TB as in Figure 2.5. The rest need between 1 TB and 1 PB, more than 1 PB, or simply do not know how much they need. Early-career researchers seem to need slightly less data storage than senior researchers.

Good Practice on Data Storage: EUDAT is a European network of data centres for researchers from all disciplines to preserve, find, access, and process research data.[38] Their B2SHARE and B2DROP services offer researchers a safe repository and cloud workspace.

Figure 2.5: Missing support and type and amount of digital content created.



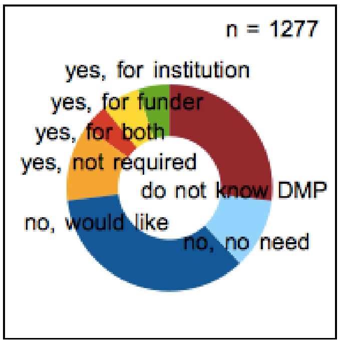
37 https://www.openaire.eu/

38 https://www.eudat.eu/

A Data Management Plan (DMP) is a formal plan which outlines how researchers will handle their data, both during and after completing a research project. A DMP thus helps researchers plan and track the creation of research data. For example, in the Horizon 2020 Open Data Pilot,[39] researchers are required to submit a first version of their DMP within the first 6 months of the project and to update the DMP whenever significant changes arise.[40] Only a quarter of survey respondents have actually used a DMP, however, in their research as in Figure 2.6, one third has not used a DMP but would like to, while a quarter do not even know what a Data Management Plan is. Early-career researchers are less likely to use a DMP than senior researchers and are more likely than senior researchers to not know what a DMP is and be interested in using one.

Good Practice on Data Management: The Digital Curation Centre (DCC) is a centre of expertise which focuses on building capability and skills for research data management.[41] The DCC provides information and support on DMPs along with a web-based tool DMPonline.[42]

Figure 2.6: Use of a Data Management Plan.



2.5. Practising Open Science

Having set the political framing and researchers' awareness of Open Science then trained them and provided them with adequate infrastructure and support, the next step is for researchers to start practising Open Science. A general observation is that early-career researchers are less advanced in Open Science: senior researchers are more knowledgeable of policies, opportunities, and practices for Open Science. While this may simply be due to the experience of senior researchers, the survey nevertheless does not support the notion that 'data natives' are the frontrunners of the Open Science 'revolution'. Knowing to what extent researchers publish in Open Access, as well as where they store their data and how they archive data, enables institutions to tailor their policies and develop relevant skills courses and professional development for researchers.

When looking back over the last five years, most researchers are producing 1-5 publications, followed by 6-10 and 11-20 publications, as in Figure 2.7. A small minority has not yet published while another minority exceeds 21 publications. A small group is interestingly not sure of the number of publications. Note that the survey question simply asked for the number of publications and did not specify what exactly was understood by a publication.

When we zoom in on where these publications can be found, we see that a large number of researchers are not publishing in Open Access journals or depositing their publications in Open Access repositories as in Figure 2.7. A surprising number of researchers does not know whether they have actually published in an Open Access journal or repository. This ties in with the general lack of awareness of researchers of Open Science practices and specifically Open Access. The remaining researchers publish to varying degrees in Open Access journals and repositories.

39 https://ec.europa.eu/research/press/2016/pdf/opendata-infographic_072016.pdf

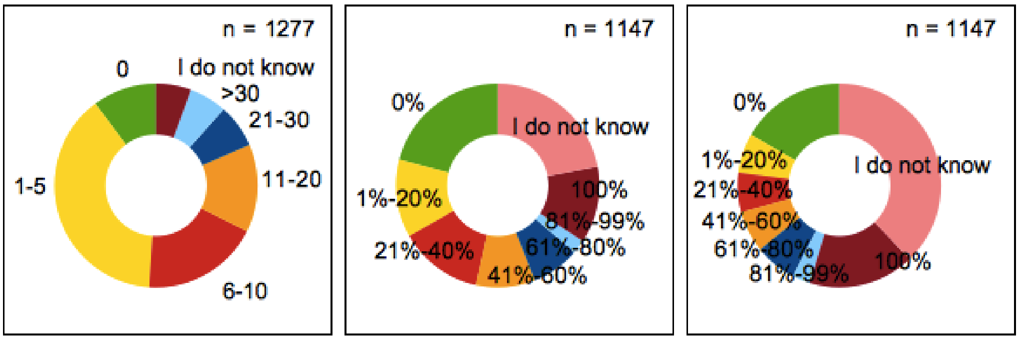
40 http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf

41 http://www.dcc.ac.uk/

42 https://dmponline.dcc.ac.uk/

Good Practice on Open Access: The Fair Open Access Alliance (FOAA) is a network of scholars and librarians who aim to sustainably return control of scientific publishing to the scholarly community.[43] Member organisations include LingOA, MathOA, and PsyOA.

Figure 2.7: Articles published in last 5 years, in Open Access journals, and in repositories.



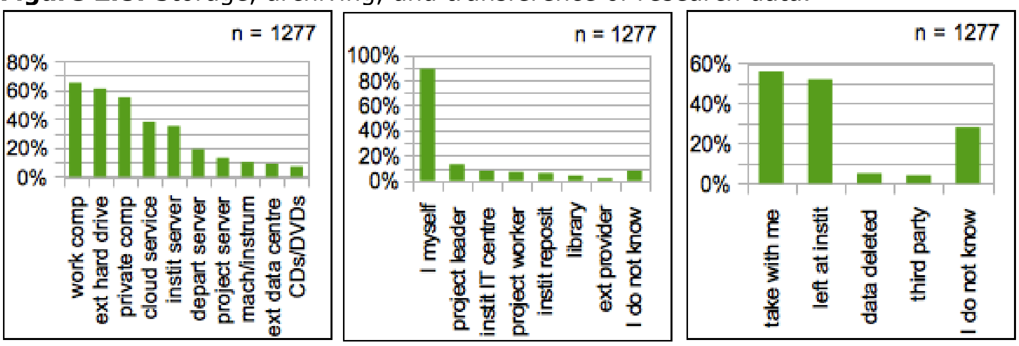
Once research data have been created, they needs to be stored somewhere safely, a topic addressed by the European Open Science Cloud WG under the Open Science Policy Platform (OSPP).[44] Many researchers store their data in more than one place as in Figure 2.8. This is most often on a work computer, an external hard drive or USB drive, or a private computer, all of which are inaccessible to others. Some researchers store their data in a cloud service or on a server of their institution, while others use a server of their department/institute or even a server of their project group. It is interesting that older forms of data storage are decreasing in use: very few researchers use CDs/DVDs and only almost nobody still uses magnetic tapes for storage.

When it comes to archiving research data, it is clear that researchers themselves are mainly responsible for archiving their own data as in Figure 2.8. For a minority, the project or group leader, an institutional IT centre, a project or group assistant, an institutional data repository, the library, or an external service provider may be responsible. Only a small percentage is unsure who should archive their data. The fact that researchers themselves must archive their data means that they need to be made adequately aware and trained in research data archiving.

When asked what will happen to their data, should they leave their institution, just over half of researchers say that they will take their data with them and/or that their data will remain at the institution as in Figure 2.8. Only a small number say that their data will be transferred to a third party and/or will be deleted. Just over a quarter does not know what will happen to their data. One wonders if the institutions actually know what happens to much of their research data. Early-career researchers are less inclined than senior researchers to take their data with them and are more inclined than senior researchers to not know what will happen with their data.

Good Practice on Archiving: Ghent University has an Immediate Deposit/Optional Open Access mandate for publications.[45] All research output from 2010 is registered in the Academic Bibliography and Institutional Repository, with an electronic full-text version attached.

Figure 2.8: Storage, archiving, and transference of research data.



43 https://fairoa.org/2017/02/28/hello-world/

44 http://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud

45 https://lib.ugent.be/en/info/open

2.6. Accessing Open Science

An important aspect of Open Science is that research is Findable, Accessible, Interoperable, and Reusable (FAIR).[46] This means that interested parties must be able to search for, find and access research as well as be able to understand and use the research data. These principles are crucial to accessing Open Science and essentially make Open Science open. This access helps in maintaining and checking the quality of research and thus contributes to research integrity.

Almost two thirds of researchers grant access to their data to research project/group members and almost half grant access to interested persons by request, as in Figure 2.9. The remaining researchers grant, to a lesser extent, access to members of their institution, to their own scientific community, or are totally open and grant access to everyone. A minority leave the decision to their funder and follow funding guidelines, while others do not grant any form of data access.

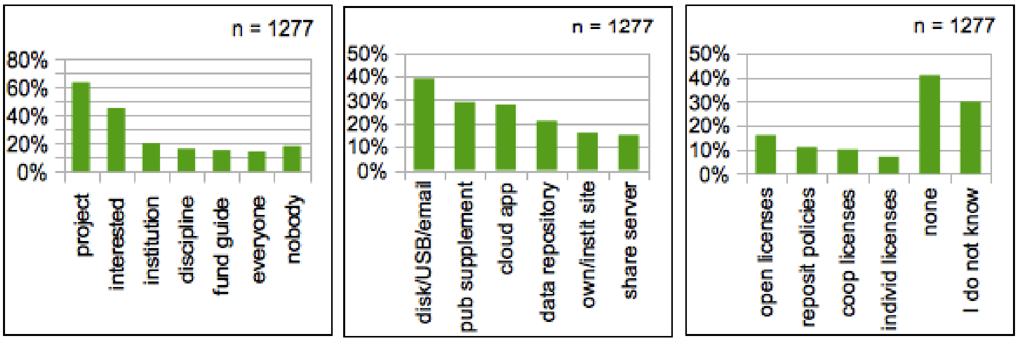
The typical way for researchers to grant access is via physical disks/USB/email, as supplementary material with publications, and via cloud applications. Data repositories, remote servers/share drives, and/or personal/institutional websites are also used to some extent. Early-career researchers use data repositories and their personal/institutional websites less than senior researchers. Access to data is thus granted via relatively closed media. Skills training needs to highlight the benefits of more open sharing of research data.

Good Practice on Granting Access: The Language Archive of the Max Planck Institute for Psycholinguistics employs four levels of access to data stored in the archive: fully open, restricted access for registered users, access by request only, and access solely for depositors.[47]

There are various types of user agreements which can be put in place for access to research data. The most common type of user agreement is an open content license, such as a Creative Commons or general public license as in Figure 2.9. Researchers further adhere to policies of the data repository where they place their data or issue cooperation agreements or individual license agreements. It is clear that most researchers either do not issue or simply do not know about user agreements. Early-career researchers tend to issue less user agreements and say they know less about user agreements than senior researchers. The more technical and infrastructural sharing options are thus used less, which may reflect a lack of skills training for these options, and which should be included in Open Science training courses.

Good Practice on User Agreements: Creative Commons (CC) is a non-profit organisation which promotes the sharing and reuse of creativity and knowledge.[48] CC supports Open Science with different CC licenses and public domain tools for sharing research and data.

Figure 2.9: Who gets access, how they get access, and user agreements.



An important aspect to releasing research data is that it is accompanied by metadata. This is basic information about the data that makes it more accessible to users and helps them understand and use the data. Two out of four researchers provide their research with metadata, whereby they

46 https://ec.europa.eu/research/openscience/index.cfm?pg=home

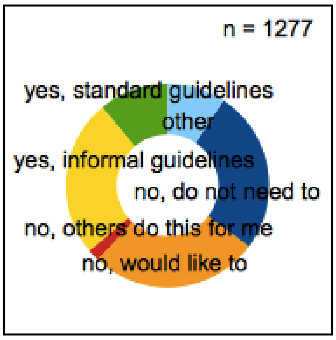
47 https://tla.mpi.nl/

48 https://creativecommons.org/

usually use their own/informal guidelines, rather than standard institutional/disciplinary guidelines. Almost two thirds do not provide any metadata, whereby they say they would either like to use metadata or do not feel any need for metadata. The majority of data thus seems not to be coupled with metadata. Standard metadata guidelines, institutional or even disciplinary, are essential for Open Science and should be included in institutional practices and skills training courses.

Good Practice on Metadata: The Norwegian Centre for Research Data (NPD) obliges all data stored in the archive to be provided with metadata.[49] This metadata is systematically based on archiving forms, questionnaires, and reports/summaries from the data owner.

Figure 2.10: Use of metadata.



2.7. Rewarding Open Science

A final step is actually rewarding Open Science so that researchers see the benefits of practising Open Science and continue to do so. This step feeds back into the initial step of framing Open Science, making researchers more aware of and helping shape policy on Open Science, as well as encouraging other researchers to also begin practising Open Science.

Visibility and impact of research are clearly what most motivates researchers to make their research available via Open Access as in Figure 2.11. The vast majority of researchers find it important for maximising the visibility of research, providing free access to a wide audience, and promoting the work of researchers. Increasing the number of citations and reducing publishing costs in journals are also considerable motivators, as well as better research assessment and monitoring and better career development and chances of promotion. Enabling the reuse of data and recognising time spent on publishing articles also score quite high.

Good Practice on Rewarding Open Access: Indiana University-Purdue University Indianapolis (IUPUI) has started to reward Open Access scholarship in its staff promotion and tenure guidelines in order to promote Open Access practices under researchers.[50]

When it comes to openly sharing research via Open Data, the most important motivators are increased visibility and impact of research, new contacts/opportunities for cooperation, and possibilities for data to be cited as in Figure 2.11. Many researchers also find recognition for their work in both the scientific community and in project/career evaluations. Other motivators to openly share data are financial support, appropriate use of data, and technical support for making data accessible. Interestingly, the least important motivator is recognition by the general public. Understanding what motivates researchers the most to do Open Science is important for setting up successful rewards criteria and implementing relevant skills training.

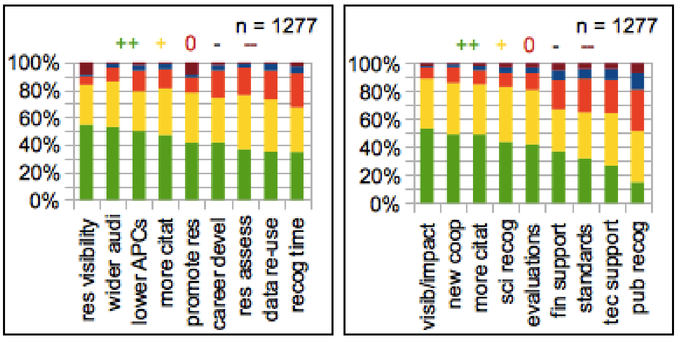
Good Practice on Rewarding Open Data: The Open Science Framework (OSF) is an open source service from the Centre for Open Science which encourages journals to reward researchers with badges in publications for sharing data and (preregistered) methodology.[51]

49 http://www.nsd.uib.no/nsd/english/index.html

50 https://scholarworks.iupui.edu/bitstream/handle/1805/10343/322.full.pdf

51 https://osf.io/

Figure 2.11: Motivators to publish in Open Access (right) and share in Open Data (left).



In summary, the survey results show that researchers are largely unaware of Open Science policies and practices, require more skills training and support to practise Open Science, and need to be incentivised to begin, and continue to practise, Open Science. In the next sections, we will look more closely at the skills researchers need for Open Science and will make recommendations to facilitate Open Science. For more detailed recommendations on incentivising and rewarding researchers for practising Open Science, we refer the reader to reports from the Working Group on Altmetrics under Open Science[52] and the Working Group on Incentives & Rewards under Open Science[53].

3. OPEN SCIENCE SKILLS FOR RESEARCHERS

Chapter 3 will give an overview of Open Science skills for researchers in modern technological and data intensive research environments. These environments are undergoing rapid change; they require integrated solutions from a lot of different actors. Thus, national, regional and institutional Open Science roadmaps will be needed to address the new challenges in a coherent way.

For education, training and research, this means that there shall be new approaches and closer contact and collaboration between schools and higher education, and research institutions and the European Research Area (ERA) should work in closer collaboration with the European Higher Education Area (EHEA). [54] Furthermore, related ministries of education and research, administrations, funders and employers and other stakeholders in the process should build modern frameworks and joint infrastructures, addressing current and future challenges, enabling the next generations of researchers to evolve as Open Science citizens. This also was reflected in the Council conclusions of the Slovak Presidency in 2016, where the Bratislava Declaration of Young Researchers[55] was adopted, which contain a set of commitments to create better conditions for new generations of scientists and researchers which, as the driving force for innovation and economic growth, are of vital importance to Europe's future competitiveness and leadership.[56]

Open Science skills should be embedded within formal education from the earliest possible stage; these skills need to be embodied in all members of society. Researchers come from, and remain part of, that broader society. Research careers from the doctoral career stage (R1) to the Leading Researcher stage (R4) are not always (or even most often) a continuum: researchers can depart from the formal research environment at any stage and most researchers at the R1 and R2 levels will do so to take up other careers. It is here suggested that Open Science skills are no less relevant to them as a result, just as they are to all citizen scientists, to those employed in industry, the professions, the media and elsewhere. If Open Science is to have any meaning, it must become a fundamental and integral part of open government, engaged citizenship and the knowledge society. Therefore, Open Science skills must be integrated within formal structured education through elementary school, high school and further and higher education – as well as through professional skills training and through lifelong learning.

52 https://ec.europa.eu/research/openscience/pdf/report.pdf

53 The report from the Working Group on Incentives & Rewards under Open Science is expected to be published in July 2017.

54 https://ec.europa.eu/research/era/pdf/era_progress_report2016/era_progress_report_2016_technical_report.pdf

55 http://www.eu2016.sk/data/documents/bratislava-declaration-of-young-researchers-final.pdf

56 www.consilium.europa.eu/en/meetings/compet/2016/11/st14926_en16_pdf/

3.1. Categories of Open Science Skills

Aligned with the EU Open Science Monitor,[57] researchers' Open Science skills can be regrouped into four larger categories, *i.e.*:

- Skills and expertise necessary for open access publishing.
- Skills and expertise regarding research data, data production, management, analysis/use/reuse, dissemination and a change of paradigm from "protected data by default" to "open data by default", respecting legal, and other constraints.
- Skills and expertise to act in and beyond one's own scholarly and disciplinary community.
- Skills and expertise resulting from a general and broad concept of citizen science, where researchers interact with the general public to enhance the impact of science and research.

All of these skills are needed at different levels by the research system, whether by researchers or technicians as well as support and administrative staff, depending on the role that these various functions have in an Open Science research environment.

- **Skills Related to Open Access Publishing**

Library and research information skills (technical/library research support). These refer to a rapidly evolving specialist skill-set amongst a specific cohort of academic and research library and information professional staff which includes research support, development and management of CRIS (current research information systems) and (ideally, integrated) institutional repositories, some discipline-specific e-research methods, new Open Publication strategies, in terms of contracts and relations with publishers, new funding models, and the related changes in publication modes for researchers. They include licensing and copyright advice, bibliometrics and research impact reporting. Some of these functions may be performed by research management staff.

Open publication literacy skills (research user level). These are skills researchers need to have about Open Publication options in order to make the correct choices about where and how to publish their results, how and what to self-archive and how to communicate their research for scholarly and societal impact.

- **Skills Related to Data Management and Open Data**

Technical skills, in particular data science skills. Data science skills relate to the collation of relevant scientific data, their annotation and documentation, metadata creation, use of taxonomies and ontologies, data mapping, how to handle big data sets, how to properly mine for data, knowledge about existing repositories and how to use them. We note that a distinction should be made between researchers and technicians that are at the 'core' of data engineering who usually have an IT, mathematics, statistics or engineering background, and researchers from other disciplines that consider technical skills such as data management to be an addition to their primary research field. For the latter, user level data science literacy is sufficient, while the first category is driving technical innovations for data management and Open Data (including developing standards and interoperability) and supporting researchers in the development and technical configurations of research platforms or databases. Technical skills are generic to a certain degree, but they are mainly discipline specific. Nevertheless, the interaction between disciplines around databases and data methodologies may bear potential for new interdisciplinary research and research methodologies. The EDISON[58] project provides a description of the qualifications, skills, competences and training required for data professionals as in Figure 3.1.[59]

We note that of the data science skills and expertise quoted above, data engineering, data analytics and big data skills currently seem to be in the focus of a lot of new HEI curricula. Examples of this can be found in most European countries, a more specific example (of many) being the Swiss Data Science Centre (SDSC).[60]

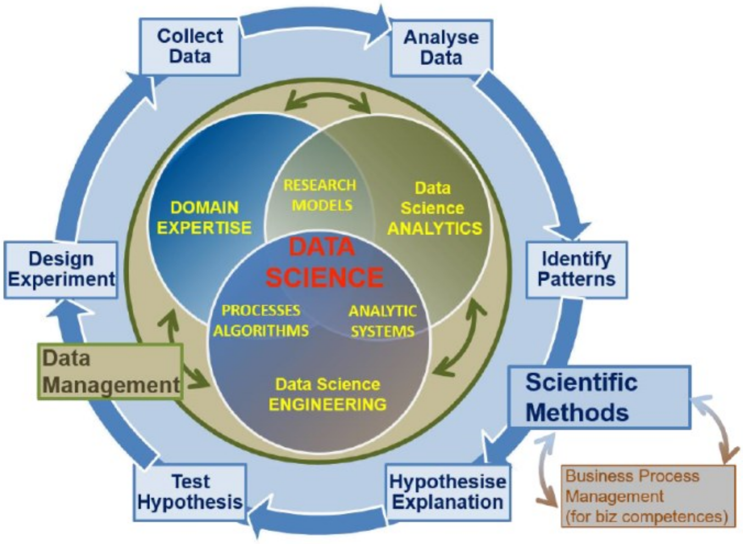
57 http://ec.europa.eu/research/openscience/index.cfm?pg=home&section=monitor

58 http://edison-project.eu/

59 Data Science Competence Framework (CF-DS): Approach and Working Version, Yuri Demchenko, Adam Belloum, Tomasz Wiktorski, EDISON (Education for Data Intensive Science to Open New science frontiers) Discussion Document, July 2016. http://edison-project.eu/sites/edison-project.eu/files/filefield_paths/edison_cf-ds-draft-cc-v07_0.pdf.

60 https://datascience.ch/

Figure 3.1: Data Science competence groups for general or research oriented profiles.



- **Skills Enabling Professional Research Conduct**

Research management skills. In particular leadership, management and soft skills are required to build positive and trusting working environments. Professional collaboration frameworks between academia and industry or other sectors will need to be developed to enable Open Science. Knowledge of IP and entrepreneurship is of specific importance for potential commercial applications. Researchers should be entrepreneurial, know how to acquire funding, how to balance potential conflicts between Open Science developments and legitimate IP interests which requires communication and leadership skills, beyond mere legal skills.

Legal skills. Researchers are often unaware of the entire spectrum of legal aspects related to IP and copyright, as well as the use of data and information which may be considered sensitive. Data protection requirements may go against Open Science, and there may be discipline specific legal aspects. Current policies regarding research data are often contradictory, depending on whether the potential IPR protection interest or the FAIR data concern prevails. In this regard, the recent EU Data Directive[61] will pose significant challenges for researchers and institutions practicing Open Science.

Research integrity and ethics skills. Open Science poses challenges on research integrity that researchers are not necessarily aware of. Due to the ease of access to all kinds of open source information, a copy-paste mentality has developed that has resulted in increased cases of plagiarism. Researchers at all career stages need to be sensitised to the importance of correct quotation and proper attribution of research, to the handling of sensitive data (*e.g.* patient information), in sum to all aspects that correspond to professional conduct in research. It is important to address these issues in a prudent way, enabling trust. Most cases of research integrity are cases of neglect rather than fabrication, falsification or fraud. A clear distinction with appropriate measures needs to be made between the two. This requires ethical skills and cultural as well as regulatory aspects of data handling – beyond the mere technical aspects. In addition, while courses on all aspects of research integrity should be offered, there should also be a focus on Open Science through scenarios, case studies and active and independent learning.

- **Citizen science Skills**

Citizen science skills are a relatively new concept. In addition to enabling the practice of science by members of the public, they are about researchers learning how to engage with citizens, including how to communicate with stakeholders other than researchers or the academic scholarly community, in view of a better user involvement and dissemination of research results. In the medical sector, the concept is probably most advanced through patient involvement. These skills encompass: the capacity to adequately include citizens in the research design and development processes when relevant, the capacity to involve citizens in the collection and analysis of research data, for example through citizen science platforms such as Socientize,[62] and finally the capacity to

61 http://ec.europa.eu/justice/data-protection/

62 http://www.socientize.eu/?q=eu/content/socientize-0

communicate, but also explain and discuss research results with the general public in an easily-understandable fashion to foster interest in science and research, build a relationship of trust with society and allow citizens to gain the knowledge and skills that will allow them to debate with scientists and policy-makers about scientific issues and potential priorities in an informed manner. Examples are visits of researchers in schools, science weeks or festivals such as the European Researchers' Night,[63] or public debates organised on societal issues with scientists and policy makers.

3.2. The Current Open Science Skills Provision Landscape

A large number of research and innovation stakeholders are currently active in the provision of Open Science skills in Europe, as in Figure 3.2. Greater coordination across these stakeholders is recommended to combat the issue of fragmentation and possible duplication. The European Commission can play a role in the standardisation of a set of recognised skills, competences and supports, which can then be coordinated across the current landscape utilising the expertise and networks of these agencies. Some examples of current activities are provided below.

A recent SPARC Europe[64] report surveyed the scene and provides an extremely valuable overview of the current picture across a mix of projects (*e.g.* OpenAIRE), inter-university collaboration centres (*e.g.* the Digital Curation Centre (DCC), national infrastructure organisations (*e.g.* JISC[65] and international organisations (*e.g.* COAR,[66] Knowledge Exchange,[67] IFLA,[68] and SPARC Europe,[69] see Figure 3.2).

Of the eighteen stakeholders who provide workshops, OpenAIRE, JISC, SURF, IFLA, Right to Research Coalition[70] and the Digital Curation Centre also provide other training and educational activities, including webinars, and thus it can be concluded that training and education is a priority for these organisations. Of the thirteen agencies who provide training and educational activities, eight also provide webinars. These include OpenAIRE and FOSTER as European Commission projects, as well as JISC, SURF, IFLA, the Right to Research Coalition, DCC and ALPSP.[71] COAR and OASPA[72] currently only provide webinars. The SPARC Europe report also reveals the target audiences of these activities, showing that all levels of researchers, support staff, data stewards and policymakers at European, national, regional and local level are included. In addition to the work of agencies at the international level, Open Science skills provision shares approaches, methodologies, policies and knowledge with other highly complementary skills programmes currently active at the institutional level, for example many universities provide training in research ethics and research integrity, in scholarly communication and research impact, information literacy, data management as well as in Open Access itself.

Despite all of the above activity, the results of this report's survey clearly indicates that Open Science skills training is perceived as lacking for researchers at all levels. It should be noted that it is not just *what* is delivered in terms of Open Science skills training: *how* it is delivered is at least as important. Respondents reported the opportunities for skills development as better through actual practice than through training courses. Therefore, the means of delivery and the teaching and learning modes appropriate to the particular skills and the level of the researcher must be determined and employed. This is also true for Open Science skills training for citizens, professionals, members of the media and policy-makers.

It might be envisaged, for example, that simple approaches to data management are introduced to schoolchildren at the earliest stages as they work on school projects. Information on research information skills, intellectual property and research ethics and integrity can be integrated into the

63 http://ec.europa.eu/research/researchersnight/index_en.htm

64 SPARC Europe (2016) Mapping Open Science & Open Scholarship in Europe, December 2016, SPARC Europe. http://sparceurope.org/wp-content/uploads/2017/01/SPARCEuropeMappingOpenScienceinEurope.pdf

65 https://www.jisc.ac.uk/

66 https://www.coar-repositories.org/

67 http://www.knowledge-exchange.info/

68 https://www.ifla.org/

69 Mapping Open Science & Open Scholarship in Europe, December 2016, SPARC Europe. http://sparceurope.org/wpcontent/uploads/2017/01/SPARCEuropeMappingOpenScienceinEurope.pdf.

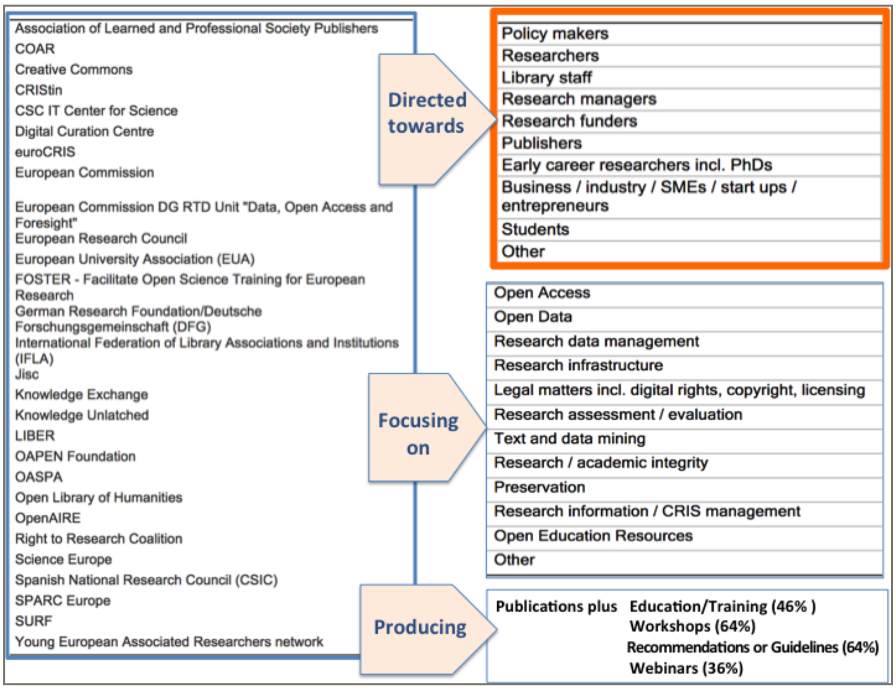
70 http://www.righttoresearch.org/

71 https://www.alpsp.org/

72 https://oaspa.org/

curriculum and conveyed through the practical work (and assessment) of older students, providing a foundation for further embedded training at undergraduate level and beyond.[73]

Figure 3.2: Research and innovation stakeholders providing training in Open Science skills (data derived from SPARC Europe).



4. ENGAGING RESEARCHERS AT ALL LEVELS IN OPEN SCIENCE

Engaging researchers at all levels in Open Science means engaging society at all levels in Open Science, and recognising that researchers and research are part of that society.

It is disingenuous to expect researchers to comprehensively and consistently practise Open Science simply because it is a 'good thing' or because it is a general but largely unenforced policy of the researcher's funder or employer. Success in achieving full engagement means not imposing a different culture and practices from the outside, but instead integrating the culture and practices within the research environment and workflow in ways that are relevant, practical and compelling to the researcher. The survey responses show the gaps in knowledge and skills of researchers in this area, along with the barriers they perceive and potential incentives they suggest. This chapter develops the concept of engaging researchers in Open Science with specific reference to the manner in which Open Science skills are structured, presented and supported.

4.1. Engaging Researchers in Open Science - Perceptions and Reality

Ten years ago, Arthur Sale's studies showed that visibility, requests, encouragement, incentives, information, assistance or even cash rewards to authors from either their institutions or their funders have little effect.[74] In fact, at most these extra inducements only increase the deposit rate to about 30%. While these incentives are important, there is no evidence to show that they provide a guarantee of deep and genuine engagement.

Harnad's (2011)[75] contention that 'the only thing that really works is deposit mandates', is supported by several international author surveys conducted by Alma Swan[76], across all disciplines,

73 For all information on the New Modernisation Agenda, please consult https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-1062784_en.

74 Sale, A. The Acquisition of Open Access Research Articles. First Monday 11(9). 2006. http://eprints.utas.edu.au/388/

75 Harnad, S. Open Access to Research. JeDEM 3(1): 33-41. 2011. P. 35. https://eprints.soton.ac.uk/272401/1/harnad-jedem.pdf.

where authors reported that they are in favour of Open Access, but that they would only make their articles Open Access if deposit were made mandatory by their institutions or funders. There is no reason to believe that this situation is any different today. Our survey respondents say that visibility and impact of research are what motivates them the most to make their research available via Open Access but, the low level of uptake of Open Access by researchers tells a different story. The link with the importance of performance evaluation is reinforced by our survey responses where, as well as better research assessment and monitoring, what motivates researchers to make their research available via Open Access is better career development and chances of promotion.

However, the survey reveals a confused situation currently pertaining in Europe. Almost half of all respondents do not know if their institutions have any guidelines for Open Access publishing. The awareness of institutional or funder mandates amongst researchers is also low, rendering those mandates ineffective. Explaining this, at least partly, is the fact that the awareness of training and support in this area has been revealed as extremely low.

It is here suggested that a number of improvements in aligning policies and coordinating efforts is required, but above all that these efforts are not only joined-up, but also updated, systemised, embedded and recognised through monitoring, accreditation, rewards and reinforcement. Additionally, it is argued that skills for Open Science embody these principles, and are the bedrock supporting the reinforcement of Open Science mandates.

76 Swan, A. The Culture of Open Access. Researchers' Views and Responses. In: Jacobs, N. (ed.). OpenAccess. Key Strategic, Technical and Economic Aspects. Oxford/Chandos. 2006. P. 52-59. 2006. http://eprints.ecs.soton.ac.uk/12428

4.2. The European Skills, Qualifications and Competencies Landscape[77]

Table 4.1: Open Science-related elements in key policy documents affecting researchers.

OECD: 7 Innovative Principles of Doctoral Training: Transferable Skills – Open Science elements	Open Science & EC 8 Key Competences for Lifelong Learning – Open Science elements	European Charter for Researchers: Open Science-related elements for Researchers	European Charter for Researchers: Open Science-related elements for Employers & Funders
Research competencies: Grant application writing skills; Research management & leadership; Knowledge of research methodologies & technologies; Research ethics & integrity. Communication skills: Communication & presentation skills, written & oral; Communication & dialogue with nontechnical audiences, public engagement; Teaching skills; Use of science in policymaking.	Digital competencies: Confident and critical usage of information and communications technology for work, leisure and communication. Learning to learn: Ability to effectively manage one's own learning, either individually or in groups. Social and civic competencies: Ability to participate effectively and constructively in one's social and working life and engage in active and democratic participation, especially in increasingly diverse societies.	Intellectual freedom; Adherence to recognised ethical practices; Professional responsibility; Professional attitude; Contractual and legal obligations; Accountability; Good practice in research (e.g. reliable backing up of data); Dissemination and exploitation of results is promoted; Public engagement is promoted; Researchers should take advantage of available supervision in a structured way; Senior researchers have a responsibility to manage and nurture younger researchers well; Continual professional development is promoted	Recognition of researchers as professionals on a career path (from postgraduate level upwards); Research environment should be stimulating and safe; Career development should be promoted; Access to research training and continuous development; Intellectual property rights should be protected; Co-authorship should be viewed positively; Evaluation/appraisal systems should be provided

In order to achieve engagement of researchers at all levels in Open Science, not only does a level of coordination, standardisation and accreditation need to be achieved, it is also recommended that the current policies applicable to the European (and broader) research community are reassessed in the context of Open Science and that the existing Open Science-related elements are made explicit. This will result in a clear policy alignment for Open Science and will provide clarity to policymakers at the national, funder and institutional level as well as to researchers themselves. Table 4.1 shows a current high degree of alignment on Open Science-related topics that is implicit in a number of key policy documents in Europe. It is suggested that this alignment is mapped in greater detail and developed into practical implementation for specific levels of researchers (embedding into doctoral training would be a good start).

77 See also https://ec.europa.eu/ploteus/search/site?f[0]=im_field_entity_type%3A97 and http://www.cedefop.europa.eu/en/events-and-projects/projects/european-qualifications-framework-eqf.

4.3. A European Skills and Qualifications Matrix for Open Science

There are gaps currently in the European classifications and competencies for Open Science, for example, Open Science is largely missing from the Digital Skills Competence[78] document and associated EuroPass[79] guidance. These gaps afford opportunities to fully embed Open Science skills into all parts of the European skills and qualifications structures and frameworks. These opportunities include the following:

- Map the Foster Open Science Taxonomy into the ESCO taxonomy;[80] create an Open Science Competence Catalogue.
- Assign the appropriate levels of competence and map these to Open Science skills requirements for all researchers plus key target groups.
- Differentiate teaching/learning modes and associated accreditation and recognition mechanisms.
- Align the above structure with the Lifelong Learning initiative and employ its concepts and terminology in order to embed Open Science in society at all levels.
- Integrate within the career development systems of researchers at all levels.
- Reinforce with additional incentives and rewards for researchers.[81]

When developing new Open Science skills frameworks, there is an opportunity to focus on doctoral candidates, as they are the emerging new generation of researchers. This could be done by embracing the Innovative Doctoral Training Principles into the Open Science mechanisms. This will require a root and branch approach to embedding Open Science in all seven of the Innovative Doctoral Training Principles. Once the alignment highlighted above is achieved, it will be necessary to ensure that researchers at all levels are not only *aware* of the skills and qualifications structures and frameworks, they should also understand that these skills and qualifications are essential to their successful careers in research and, within this context, relevant Open Science courses should be developed, taught and evaluated. This will take a huge shift in current perceptions, where, as shown in our survey, both the Charter for Researchers and Code of Conduct for their Recruitment and the Human Resources Strategy for Researchers are to a large extent unknown to researchers.

It is proposed that Open Science mandates from funders and institutions include explicit requirements for Open Science skills training for researchers and that Open Science skills training is designed to be aligned, coordinated, embedded, standardised, iterative, scalable, transferable, open, adaptable, rewarded and above all, mandatory.[82]

It is also proposed that Open Science mandates are monitored and reinforced and rewarded, accompanied by the highest degree of professional visibility, and supported by Open Science skills training.

As stated throughout this document, engagement in Open Science should be viewed in its broadest sense and needs to include citizen scientists and interaction with civil society, media and communication professionals including publishers, medical, legal, engineering and other professionals. Particular attention needs to be paid to developing and growing the cohort of information professionals (which can include librarians, data scientists, data stewards and others). The EDISON project has provided an in-depth description of the qualifications, skills, competences and training required for data professionals. We note here also that, related to this, implementing Open Science practices will also require a new workforce of data stewards who will support researchers, and thus this also opens up new employment opportunities for researchers in all disciplines.[83] These data stewards need to be adequately trained, not only to support researchers in Open Science but also to realise the European Open Science Cloud, and they themselves will need to be supported in their tasks (*e.g*. by setting up national institutes for data stewardship).[84]

78 https://ec.europa.eu/digital-single-market/en/digital-skills-jobs-coalition

79 http://europass.cedefop.europa.eu/

80 https://ec.europa.eu/esco/portal/home

81 See the report from the WG Incentives & Rewards under Open Science.

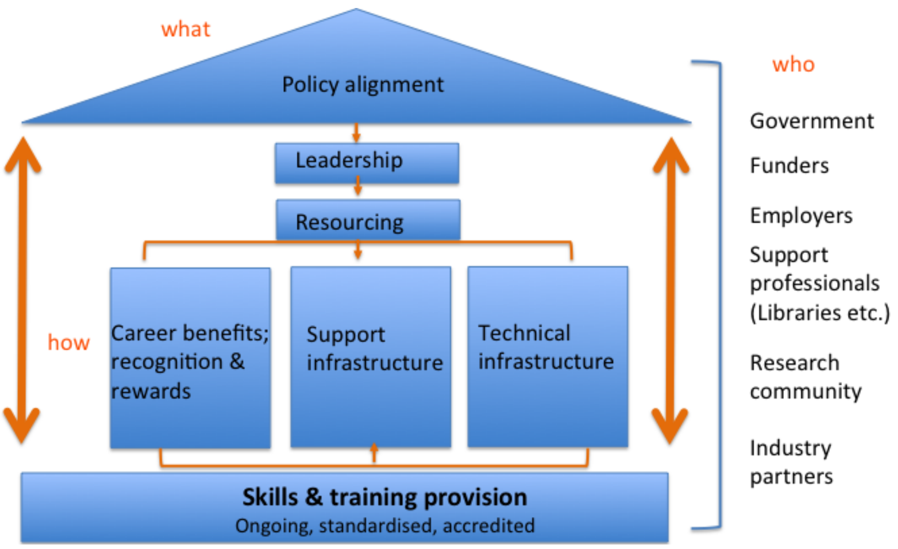
82 http://www3.weforum.org/docs/WEF_EGW_Whitepaper.pdf

83 https://joinup.ec.europa.eu/community/opengov/news/500000-data-scientists-needed-european-open-research-data

84 https://ec.europa.eu/research/openscience/pdf/realising_the_european_open_science_cloud_2016.pdf

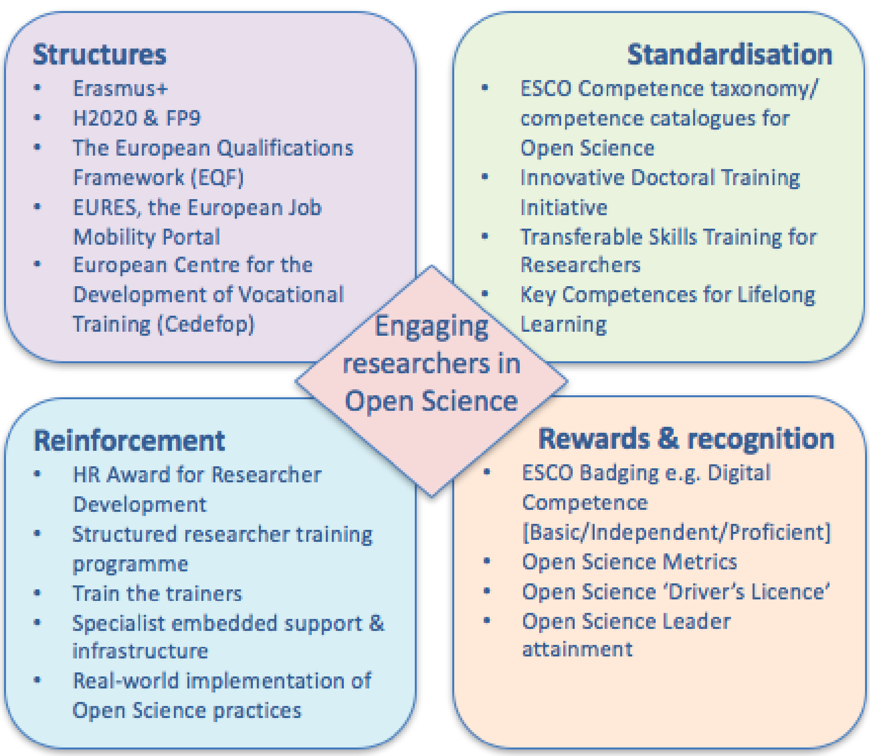
A similarly in-depth approach needs to be undertaken to determine the competences and training required for specialist Open Science librarians. The provision of funding to support the development and recruitment of these information professionals needs to be acknowledged and provided. However, training, by itself, cannot guarantee engagement. Skills provision and training, even when standardised and accredited, will be less effective unless it underpins and is part of a coherent and coordinated structure of policies supported by leadership and resourcing, reward systems and incentives and backed by all entities involved in European research at every level. Figure 4.3 is a representation of that structure and the recommendations offered in this report are made with this structure in mind.

Figure 4.3: Engaging researchers at all levels: supporting structure.



Finally, within the context of the supporting structure outlined above, a simple and practical European Skills and Qualifications matrix for Open Science is offered in Figure 4.4 below, to bridge the gaps and support engagement at all levels.

Figure 4.4: A European skills and qualification matrix for Open Science.



5. OPEN SCIENCE EMBEDDED IN ERA POLICY

5.1. ERA Policy and alignment with the Open Science Agenda[85]

The purpose of ERA policy is to achieve a European unified research area open to the world based on the internal market, in which researchers, scientific knowledge and technology circulate freely. The current ERA policy focuses on the five priorities that were agreed in 2012. ERA policies and ERA partnership need to be seen through the lens of Open Science and future policies and framework programmes will ensure compatibility between ERA and Open Science. In terms of the mandate of the WG on Education & Skills, the focus is on priority 3, which concerns policy on researchers. The main policy currently in place is the Charter and Code for Researchers, which is a set of 41 general principles and requirements which specifies the roles, responsibilities and entitlements of researchers, as well as of employers and/or funders of researchers. The Code of Conduct for the Recruitment of Researchers consists specifically of principles and requirements that should be followed by employers and/or funders when appointing or recruiting researchers. The Charter and Code was developed in 2005, and, while it has no explicit references to Open Science, it certainly has nothing to hinder Open Science. On the contrary, in Chapter 4 it can be seen that there is a high degree of implicit compatibility with Open Science. There are a number of policies that were developed based on the Charter and Code. For example, the European Framework for Research Careers (EFRC). The EFRC has been expanded to identify the detailed Open Science skills needed for researchers at their early careers until leading researchers in academic and non-academic settings (see Appendix 4 for details).

5.2. The Human Resources Strategy for Researchers (HRS4R)

The 'HR Strategy for Researchers' supports research institutions and funding organisations in the implementation of the Charter & Code in their policies and practices. As the application of the Charter and Code is mandatory for all Horizon 2020 contracts (Art. 32 of Model Grant Agreement), the HRS4R is the recommended means for implementation. The 'HR Excellence in Research' award, attained after a thorough analysis of an institution's HR policies has been carried out, identifies the institutions and organisations as providers and supporters of a stimulating and favourable working environment for researchers. It follows that embedding Open Science in the HRS4R will also help embed Open Science practices. In particular, the HRS4R should include specific reference to Open Science professional development for researchers through skills training and experiential learning as part of career development. Moreover, these skills should be formally accredited, recognised and rewarded as part of career progression.

5.3. The Doctorate and the Innovative Doctoral Training Principles (IDTP)[86]

The most formative stage of a researcher is during the doctorate. The Salzburg Principles (2005) are a set of recommendations from the Bologna Process for reforming doctoral education in Europe.[87] The recommendations, which included a series of pointers for success and a list of obstacles to overcome, have three overarching messages:

- First of all, doctoral education has a particular place in the European Research Area and the European Higher Education Area. It rests on the core component of doctoral training which is "the advancement of knowledge through original research". The practice of research makes the doctoral, third cycle fundamentally different from the first and second cycles.
- Secondly, doctoral candidates must be allowed independence and flexibility to grow and develop. Doctoral education is highly individual and by definition original. The path of progress of the individual is unique, in terms of the research project as well as in terms of the individual professional development.
- Lastly, doctoral education must be developed by autonomous and accountable institutions taking responsibility to cultivate the research mind-set. Institutions need flexible regulation to create special structures and instruments and continue advancing European doctoral education.

85 http://ec.europa.eu/research/era/era_communication_en.htm

86 https://euraxess.ec.europa.eu/belgium/jobs-funding/doctoral-training-principles

87 http://www.eua.be/eua/jsp/en/upload/Salzburg_Report_final.1129817011146.pdf

The recommendations have since been revisited (2010)[88] and expanded upon (2016)[89] and continue to provide guidelines for the implementation of reform in doctoral education in Europe. In particular this makes clear reference to Open Science.

There is the real opportunity here to integrate Open Science skills into doctoral education and training. It is clear that there are skills for Open Science that transcend disciplines, in addition to ones that may be relevant for specific areas. In all cases, it is important that these will be developed, accredited and, moreover, recognised in a manner that is consistent with institutional and national practice. This should certainly be the case for universities and research organisations with formalised doctoral training. However, the diversity of practice in doctoral training across disciplines and institutions must be taken into account and there cannot be a one size fits all approach. The Innovative Doctoral Training Principles that were developed based on the Salzburg Principles need to be re-examined within the framework of Open Science and should be adapted and rewritten to focus on Open Science as follows:

1. Research Excellence - that adopts the Open Science practice of sharing data
2. Attractive Institutional Environment - that supports open data with the necessary training and support staff and has institutional open repository for both data and publications.
3. Interdisciplinary Research Options - ensuring interoperability of data across disciplines.
4. Exposure to industry and other relevant employment sectors - ensuring that data and output remains as open as possible taking into account any commercial and other issues.
5. International Networking - to expand the Open Science community
6. Transferable Skills Training - that includes training on Open Science (including data management, research integrity and citizen science)
7. Quality Assurance - that ensures the practice of Open Science is recognised and rewarded as part of progression towards the doctorate.

The Innovative Doctoral Training Principles should thus be integrated into Open Science in the same way that the European University Association has integrated the Salzburg Principles into Open Science.

The survey showed that not only were researchers largely unaware of the Charter and Code and the HR Strategy for Researchers, but that they were also largely unaware of the Innovative Doctoral Training Principles. Future policies should take this into account and promote more awareness of these initiatives, integrated into Open Science practices, among institutions and researchers.

The concept of the Doctorate in Europe is that doctoral training across Europe should be provided based on the Charter and Code and specifically the Doctoral Training Principles by integrating Open Science into the principles. It identifies it as a core part of the Doctorate in Europe and should act as a magnet to attract prospective researchers globally.

6. CONCLUSION AND RECOMMENDATIONS

The focus of this report is on the integration of Open Science Education and Skills into the training and professional development of researchers at all levels (R1-R4), from all fields and in academic and non–academic settings. This must be done in a way that the skills are recognised through accreditation and are comparable across countries, and that training certain skills is a means to an end, namely the mainstreaming of the practice of Open Science used by all recognised research professionals. We note also that funding agencies and research performing organisations must work in tandem to ensure that researchers have adequate access to Open Science skills training. In addition, researchers themselves at all levels are the key to practising Open Science and it will be important that policies that relate to their career development are examined to ensure that they are compatible with Open Science.

The central message from this report is that in order to change to full automatic engagement of researchers in Open Science, a radical change of culture and mind-set in the research community and stakeholders is required. This is because traditional, pre-digital, scholarly communication mechanisms and structures for rewards and recognition are deeply embedded within current academic practice and new technology was not embedded and implemented at large until recently (EOSC, Digital skills agenda). To effect this change will require a comprehensive, multi-faceted approach, which will include:

88 http://www.eua.be/Libraries/publications-homepage-list/Salzburg_II_Recommendations.pdf

89 http://www.eua-cde.org/downloads/2016_Taking%20Salzburg%20Forward.pdf

- Updated, embedded, iterative and ongoing training and professional development in Open Science (including training of a new specialised cohort of data stewards, information professionals and data scientists). This should involve a blended approach of core skills provision with active, independent, problem-based learning.

- Reinforcement through the availability of an adequate technical and support infrastructure.

- Improved rewards and recognition for researchers doing Open Science by alternate metrics.[90]

- Implementing a system of clear benefits for compliance and clear disadvantages for noncompliance of Open Science practices.

- Ongoing advocacy and leadership of Open Science at all levels.

- Policy alignment, strategic implementation and provision of funding for Open Science.

- Renewed focus on societal engagement in Open Science and the impact agenda.

- Monitoring and reinforcement of funder and institutional mandates, which should be amended to include mandated accredited Open Science skills training.

In order to glean information on the current state of knowledge of Open Science, a survey was carried out on researchers across Europe. The questions focused on a number of themes associated with the framing of policy and awareness of, training, supporting, practising, accessing, and rewarding Open Science. The survey of researchers revealed interesting results on their knowledge of Open Science and the necessary supports for them to become open researchers. As mentioned in the introduction, we note that the information gathered went far beyond just skills for Open Science, focusing also on other aspects such as infrastructure, technical support and institutional mandates, that are crucial components of Open Science practice, and that cannot be separated from skills training.

Open Science Skills

The Open Science skills for researchers in general can be classified under the four categories which are aligned to the EU's Open Science Monitor. These are:

1. Skills and expertise necessary for **open access publications**. Library and research information skills (technical/library research support); open publication literacy skills (research user level).

2. Skills and expertise regarding **research data and open access**, data production, management, analysis/use/reuse, dissemination and a change of paradigm from "protected data by default" to "open data by default". Technical skills, in particular, data engineering, data science and data management skills.

3. Skills and expertise to act in and beyond their own **scholarly and disciplinary community**. Open Science skills enabling professional research conduct which include research management skills; research integrity and ethics skills; legal skills.

4. Skills and expertise resulting from a general and broad concept of **citizen science**, where researchers interact with the general public to enhance the impact of science and research.

It must be stressed that researchers cannot be expected to be full experts in all of these, especially those related to open access publications and open data. Researchers at all levels require the necessary skills that are sufficient for them to engage in Open Science on the assumption that there is physical infrastructure in place for storing and curating publications and data. For that reason, it is imperative that the European Open Science Cloud is developed. This will also require the relevant support staff with the detailed expertise on data and software management. Moreover, institutions must have the staff in place with the necessary expertise to act as data stewards.

It has been shown how Open Science skills could be fully embedded in all parts of the European skills and qualifications structures and frameworks. It is important to understand that different

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[90] Addressed by both the Open Science WG on Incentives & Rewards and the Open Science WG on Alternate Metrics.

types of Open Science skills are required at different career stages. In addition, the broader public must be included if citizen science is to become a reality. Moreover, this must be underpinned by supportive EU and national policy and then implemented through research funders and research performers.

There is a great deal of activity in the area of Open Science skills training, and many elements of commonality and complementarity exist across the expertise provided, for example, across information literacy, research ethics, research integrity, scholarly communication and data management. These skills are usually delivered as part of a suite of skills, for example, to PhD candidates in doctoral training programmes. This in turn should lead to a situation where there will be a European Qualifications Matrix for Open Science. Such a structure would transform the current one to a highly integrated development of Open Science for researchers. It should be recognised that there can be alternatives to formal training and researchers can also acquire skills in Open Science through the practice of research. These should also be recognised as part of career assessment and development.

What is striking is the contrast between actual activity described above and the knowledge of researchers gathered through the survey. Most researchers surveyed are aware of Open Access and Open Data, but are less aware of other Open Science practices, particularly Open Education and citizen science. They are also largely unaware of international Open Science initiatives. Researchers generally seem to learn by doing when it comes to Open Science practices. Most respondents do not have access to, or are not aware of, training courses on Open Science and they indicate that they would like courses on research publishing and dissemination and also on research data management.

The recommendations seek to ensure that this situation is changed. Their focus is on Open Science skills but cannot be isolated from recommendations on broader Open Science issues. The main issue is that of the development and dissemination of Open Science skills. Therefore, the first recommendation sets down the principles for Open Science skills.

The European Commission is in a unique position as it can lead the changes, but also it has the means to implement these policies through the next funding programme (FP9). The Lisbon Treaty specifies the framework programmes as the means to implement European Research Area policies.

6.1. Recommendation 1: Open Science Policy

In order to mainstream skills for Open Science, such that they are considered an integral component of the regular education, training and career development of researchers (and also other levels of education), the following should happen:

- All ERA policies and, in particular, the ERA partnership within the Open Science Agenda should be fully embraced. If necessary, policies must be modernised and updated in order to ensure compatibility with Open Science of certain tools already in place, such as the Charter and Code, the HRS4R and the Innovative Doctoral Training Principles.
- A call for proposals should be introduced in the H2020 programme Science with and for Society (SWAFS) to fund RIA and CSA activities on the development of Open Science skills. This includes, but is not limited to, curriculum development, certification, accreditation, standards and qualifications.
- Open Science skills should be an integral part of the Work Programme 2018 – 2020 and also of the next framework programme (FP9) with dedicated actions and funding to support and promote Open Science.
- European, regional and national funders, as well as private foundations, should mandate that all researchers funded through their programmes have access to Open Science skills training as part of their training and professional development.

6.2. Recommendation 2: Guidelines to Implement Open Science

- At European level, the existing guidelines on research careers and training should be adapted to integrate Open Science, specifically:
- A revised European Framework for Researcher Careers that identifies the specific Open Science skills for researchers at all levels should be implemented.
- The HRS4R should integrate Open Science skills as part of researcher career development.

- A revised version of the Innovative Doctoral Training Principles that integrates Open Science should be adopted.
- Create a European Qualifications Matrix for Open Science (as described in 4.3 above).
- Greater coordination across stakeholders providing Open Science Skills training is recommended to combat the issue of fragmentation and possible duplication of such training in Europe.
- Given the importance of professional institutional environments for researchers' skills and expertise development, it is recommended that research funding and research performing oganisations develop an integrated Open Science roadmap available to all students, researchers and staff. Such national, regional and institutional Open Science roadmaps are essential in order to address the requirements for the effective practice of Open Science in a coherent way.
- As part of this roadmap, we strongly encourage FAIR institutional and/or funding guidelines on Open Science practices be implemented, particularly for Open Access and Open Data.

6.3. Recommendation 3: Raising Awareness of Open Science

- In order to equip researchers with the appropriate skills to facilitate Open Science, it is crucial to first promote more awareness of Open Science practices, particularly Open Access, Open Data, Open Education, Open Peer Review and Citizen Science.
- Researchers should be made aware of Open Science policy initiatives such as Open Innovation, Open Science, and Open to the World, the European Open Science Cloud, OpenAIRE, the FOSTER project, and the Open Access Button and Logo.
- Researchers should also be made aware of existing institutional and funding agency guidelines as well as existing training and development courses for Open Science.
- Researchers should lastly be made aware of the value of Open Science practices, both at the personal level with respect to career opportunities and professional development, as well as the value of Open Science to society as a whole.

6.4. Recommendation 4: Training Researchers for Open Science

- Recognising that there are already developments in Open Science skills provision, future activity must focus on improving the quality and relevance of skills for Open Science. Under this umbrella, the qualification frameworks for Open Science skills may need to be adapted or modernised. To facilitate this, institutions should offer and promote both traditional and/or online career-level appropriate Open Science training courses for researchers:
- These courses should be tailored for and delivered to researchers at all career stages (from R1 to R4).
- All Open Science skills courses should have career level appropriate accreditation and could also be modularised.
- In the case of R1 and R2 researchers, it should be mandatory for universities and research organisations to offer these as part of their training.
- In order to narrow the Open Science skills gap, researchers will need training and development to acquire and improve the following skills:
- Skills and expertise necessary for Open Access publishing and utilising Open Access repositories.
- Skills and expertise regarding Open Data and particularly data management (analysis, use, and reuse of data), metadata, and data dissemination (sharing and granting access to data).
- Open Science skills enabling professional research conduct which include research management skills, research integrity and ethics skills, and IPR and legal skills.
- Skills and expertise resulting from a general and broad concept of Citizen Science, where researchers interact with the general public (either directly in collaboration projects or indirectly through scholarly communication) to enhance the impact of science, research and innovation in society.

6.5. Recommendation 5: Providing Support for Open Science

Training courses are not enough to help researchers do Open Science but must be complemented by adequate support for Open Science. Institutions should:

- Provide the technical infrastructure for Open Science (high-speed data centres, data repositories and virtual platforms).
- Provide the technical tools to facilitate researchers in doing Open Science (software for data creation, storage, and sharing).
- Provide professional support staff for general and specialist support for researchers (data stewards, IT technicians, data scientists, legal experts, discipline specific data managers and librarians).
- Implement and promote the use of data management plans in all research projects.
- Ensure a legal framework is in place for the secure, legal, and ethical sharing of data.

6.6. Recommendation 6: Career Development for Open Science

- The acquisition and practice of Open Science skills should be an integral part of researcher professional training and career development. In this context:
- European and national public and private research funders should recognise and reward Open Science activities as part of grant evaluation criteria. For example, in the Marie Skłodowska Curie Actions, the provision of Open Science skills training should be integrated into the evaluation criteria.
- In the next framework program (FP9), an action should be developed for Open Science placements for R1 and R2 researchers, either within or separate from the Marie-Skłowodska Curie actions.
- Institutions should lastly recognise and reward Open Science training and Open Science track record in the research and career evaluations of researchers.

7. ADDITIONAL READING

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APPENDIX 1: OS SKILLS GROUP DETAILS

The ERA Steering Group on Human Resources and Mobility (SGHRM) Working Group on "Education and Skills" (OS Skills WG) met for the first time in Brussels on the 9th of September 2016, with a specific mandate to implement the building blocks necessary to ensure that all researchers in Europe have appropriate Open Science skills and support, in order to be able to easily apply Open Science research routines and practices. The aim of this working group is to ensure that skills for Open Science are an integral and streamlined component of the standard education, training and career development paths of all researchers.

The OS Skills WG will work together with the high-level advisory group "Open Science Policy Platform" (OSPP), which met for the first time on the 19th of September 2016. The OSPP has been established to advise the Commission on how to further develop and implement OS policy, support OS policy formulation and implementation, and also to provide advice and recommendations on any cross-cutting issues that affect Open Science. This group has been established within the broader context of the Open vision with the 3 Os of Commissioner Moedas (Open Science, Open Innovation, Open to the World). This group is comprised of 30 members, a full list of which can be found on the European Commission's webpage. In order to aid the OSPP in their work, the Commission has established 8 expert working groups on different issues of relevance to Open Science, including the current working group on Open Science skills, but also topics such as Open Science Recognition/Rewards, Altmetrics, FAIR data, the European Open Science Cloud, Research Integrity and Citizen Science. These expert groups work independently, and also independently advise the Commission, but the output of these different WG will ultimately flow directly into the work of the Open Science Policy Platform.

The Group is chaired by **Conor O'Carroll**, Research Policy & Funding Consultant at SciPol and chair of the Steering Group on Human Resources and Mobility (SGHRM). Other members are Co-Chair **Caroline Lynn Kamerlin**, Professor of Structural Biology, Uppsala University, Sweden; co-author of the Bratislava Declaration on Young Researchers and former Chair of the Young Academy of Europe. **Lukas Zendulka**, Ministry of Education, Slovakia and SGHRM Delegate. **Niamh Brennan**, Research Information Systems and Services, Trinity College Dublin, Ireland; OpenAire, Board Member of DART Europe and of SPARC Europe (2014-6) and. **Berit Hyllseth** Special Adviser, Research Council of Norway, SGHRM Delegate. **Ulrike Kohl**, Talent Attraction & Capacity Building, Luxembourg National Research Fund. **Gareth O'Neill**, Leiden University, The Netherlands; President of EURODOC. **Nils Woerner**, The German Rectors Conference (HRK) and EUA.

The group also was joined by staff members of the European Commission with expertise across research, employment, education. These included

Vitalba Crivello, Policy Officer A6, DG RTD, European Commission.

Chiara Riondino, Policy Officer DG EMPL, European Commission.

Julie Sainz, Policy Officer, DG EAC, European Commission

Milena Slavcheva, Policy Analyst, Knowledge for Finance Growth and Innovation, JRC Unit B7, DG RTD, European Commission.

The group was facilitated by **Rinske van den Berg**, Policy Officer B2 unit DG RTD, European Commission. There was also input from **Fabienne Gautier**, Head of Unit, DG RTD B2 - Open Science and ERA Policy, European Commission. **Annette Bjornsson**, Deputy Head of Unit, DG RTD B2 - Open Science and ERA Policy, European Commission.

The group has had a total of four meetings and received presentations and written input from a number of sources including the EUA. A survey has been conducted targeting researchers, funders and employers to gather information on the current status of Open Science skills. The following individuals presented to the group:

Chiara Riondino, DG EMPL - The Open Science Agenda and the New Skills Agenda

Johan Rooryck, Professor of French Linguistics at Leiden University
Johan was executive editor of Lingua, one of the main journals for linguistics, for 17 years. After trying unsuccessfully to negotiate with Elsevier to make Lingua a fair open access journal, Johan and the entire editorial team of Lingua resigned and started a mirror open access linguistics journal called *Glossa*. This move was completely supported by the linguistics community and may as yet start a similar trend with other journals.

Professor David Nicholas, Director, CIBER Research Ltd.
David Nicholas is one of the original CIBER founders. His interests include use and seeking behaviour in virtual spaces, the digital consumer, the virtual scholar, mobile information (information on-the-go), e-books, e-journal usage; the evaluation of digital platforms and user needs analysis.

Lidia Borrell-Damian, Research Director, European Universities Association (EUA)
Lidia Borrell-Damian has worked for EUA since 2006 and has served as Director for Research and Innovation (R&I) since January 2014. She is responsible for supporting the work and enhancing the role of universities as major research and innovation organisations at the European level.

APPENDIX 2: OS SKILLS GROUP MANDATE

MANDATE

working group on 'EDUCATION and SKILLS'

under Open Science

All researchers in Europe have the necessary ***open science skills*** *and support to apply Open Science research routines and practices*

The increasing use of digital technologies in both education and science is putting pressure on higher education institutions to adapt but also offers opportunities for those institutions who are able to change and develop new ideas of how and what to teach young researchers. It is important to stress that open science skills are a necessity for all researchers from Starting Researchers (R1 - doctoral candidates) to Leading Researchers (R4 - professor).

Today, nearly all doctoral students (or even before that) enter straight into a data-intensive environment. They need to adapt quickly to this fast- evolving research landscape to fully realise their research potential. At the same time they are the first generation of `digital natives': most of them having grown up with the web where information is expected to be available on demand and where you not only consume but also can produce. This reality, however, is not reflected in most current scientific practices so far where knowledge teaching and dissemination is still based to some extend on traditional practices (text book teaching and journal system). Researchers who have already completed a doctorate (R2) are facing the same challenges of acquiring quickly the skills for open science to develop their career. Most importantly, more senior researchers (at levels R3 and R4) need to take a lead in this area given the ever- increasing demands from funding agencies to provide open access to publications and data.

It is critical for the future of science that all researchers work with strong integrity avoiding plagiarism, falsification and manipulation of data. Therefore it is important that researchers at all levels are educated and trained in Research Integrity.

In the long term, skills for open science should be mainstreamed and considered an integral component of the normal education, training and career development of researchers.

Tasks entrusted to the working group:

- Introduce Open Science education and training that is tailored to the four research career stages (R1 to R4).
- Include **Open Science modules** with credits in all European Doctoral Training Programmes (Doctoral level), by 2020
- Revive the **Doctorate in Europe** discussion with the Steering Group on Human Resources and Mobility and link it closely to Open Science issues which will need to be incorporated.
- **Link the Innovative Doctoral Training principles to Open Science practices** to encompass an open research environment.
- Explore together with the Open Science Policy Platform how **training in Open Science practices** could be **addressed in early education** (bachelor, master, high school) and propose concrete measures to team up with existing Commission policy initiatives on Education (associate DG EAC, they have the lead).
- Discuss and develop **links between the European Skills agenda and contribution to its implementation supported by Open Science practices**.

TIMELINE:

As a general rule, working groups of the SGHRM are active for about 6 months maximum; for this reason, a sound timeline that fits on one hand the rules of the SGHRM and on the other hand the requirements from the Open Science task force and the Open Science Policy Platform, is proposed hereafter (fine-tuning during the 1st meeting of the working group).

The outcome of the discussion in this working group according to the proposed draft mandate should be ready in **'draft' version** in-time for the May/June meeting of the Open Science task force (OStf) where a presentation by a representative of the working group is expected.

A **quasi-finalised output**, having taken into account (if appropriate) comments from the OStf should be ready well before the 2017 summer meeting of the Open Science Policy Platform (OSPP).

Approval of the **finalised output document** is expected by the SGHRM in follow-up and as soon as possible in order to strive for MS take-up and implementation at national level.

A **Commission Communication** on OS being scheduled for 2018, the working group as well as the SGHRM are expected to contribute if and when appropriate, underlining the importance of the 'education and skills' issue in the political context of modernising university curricula and career development as well as the recognition of researchers as 'professionals'.

APPENDIX 3: SURVEY CONTENT

Survey on Open Science & Career Development for Researchers 2017

(1) What is your gender?

		Answers	Ratio
male		605	47.38 %
female		653	51.14 %
alternative gender identity		4	0.31 %
do not wish to disclose		15	1.17 %
No Answer		0	0 %

(2) How old are you?

		Answers	Ratio
<20		0	0 %
20-25		72	5.64 %
26-30		463	36.26 %
31-35		305	23.88 %
36-40		167	13.08 %
41-45		113	8.85 %
46-50		65	5.09 %
>50		92	7.2 %
No Answer		0	0 %

(3) What is your nationality?

		Answers	Ratio

Austria		7	0.55 %
Belgium		14	1.1 %
Bulgaria		2	0.16 %
Croatia		68	5.32 %
Cyprus		0	0 %
Czech Republic		33	2.58 %
Denmark		49	3.84 %
Estonia		1	0.08 %
Finland		26	2.04 %
France		28	2.19 %
Germany		116	9.08 %
Greece		11	0.86 %
Hungary		12	0.94 %
Ireland		66	5.17 %
Italy		119	9.32 %
Latvia		22	1.72 %
Lithuania		48	3.76 %
Luxembourg		8	0.63 %
Malta		0	0 %
Netherlands		62	4.86 %
Poland		116	9.08 %
Portugal		109	8.54 %
Romania		8	0.63 %
Slovak Republic		13	1.02 %

Slovenia		19	1.49 %
Spain		63	4.93 %
Sweden		6	0.47 %
United Kingdom		22	1.72 %
other		229	17.93 %
No Answer		0	0 %

(4) In which country do you work?

		Answers	Ratio
Austria		14	1.1 %
Belgium		15	1.17 %
Bulgaria		1	0.08 %
Croatia		62	4.86 %
Cyprus		0	0 %
Czech Republic		32	2.51 %
Denmark		113	8.85 %
Estonia		1	0.08 %
Finland		29	2.27 %
France		27	2.11 %
Germany		93	7.28 %
Greece		1	0.08 %
Hungary		8	0.63 %
Ireland		89	6.97 %
Italy		84	6.58 %

Latvia		22	1.72 %
Lithuania		49	3.84 %
Luxembourg		31	2.43 %
Malta		0	0 %
Netherlands		90	7.05 %
Poland		109	8.54 %
Portugal		107	8.38 %
Romania		4	0.31 %
Slovak Republic		12	0.94 %
Slovenia		18	1.41 %
Spain		56	4.39 %
Sweden		9	0.7 %
United Kingdom		36	2.82 %
other		165	12.92 %
No Answer		0	0 %

(5) What type of researcher are you?

		Answers	Ratio
researcher in an early stage of their research career who has not yet been awarded a PhD and conducts research under the supervision of a mentor (e.g. apprentice, intern, PhD /doctoral candidate)		620	48.55 %
researcher who has received a PhD and is engaged in a temporary and defined period of mentored and advanced research (e.g. clinical researcher, junior researcher, postdoc)		283	22.16 %
researcher who has attained a level of independence and makes a valuable contribution in terms of scientific productivity, mentoring, and fundraising (e.g. accredited researcher, assistant professor, associate professor, associate researcher, guest researcher, junior group leader, principal investigator, principal scientist, program researcher, research fellow, researcher, scientist)		243	19.03 %
researcher leading their research field who publishes influential papers and has an international reputation based on research excellence in their field (e.g. principal investigator, principal scientist, professor, program group leader, senior group leader)		101	7.91 %
other		30	2.35 %
No Answer		0	0 %

(8) In which research field is your PhD?

	Answers	Ratio
natural sciences	432	33.83 %
engineering and technology	232	18.17 %
medical and health sciences	167	13.08 %
agricultural sciences	51	3.99 %
social sciences	294	23.02 %
humanities	101	7.91 %
No Answer	0	0 %

please choose the subfield

	Answers	Ratio
mathematics	20	1.57 %
computer and information sciences	26	2.04 %
physical sciences	81	6.34 %
chemical sciences	73	5.72 %
earth and related environmental sciences	63	4.93 %
biological sciences	159	12.45 %
other	10	0.78 %
No Answer	845	66.17 %

please choose the subfield

		Answers	Ratio
civil engineering		14	1.1 %
electrical engineering, electronic engineering, information engineering		56	4.39 %
mechanical engineering		32	2.51 %
chemical engineering		18	1.41 %
materials engineering		21	1.64 %
medical engineering		15	1.17 %
environmental engineering		23	1.8 %
environmental biotechnology		1	0.08 %
industrial biotechnology		3	0.23 %
nanotechnology		14	1.1 %
other		35	2.74 %
No Answer		1045	81.83 %

please choose the subfield

		Answers	Ratio
basic medicine		33	2.58 %
clinical medicine		19	1.49 %
health sciences		77	6.03 %
health biotechnology		12	0.94 %
other		26	2.04 %
No Answer		1110	86.92 %

please choose the subfield

		Answers	Ratio
agriculture, forestry, and fisheries		15	1.17 %
animal and dairy science		10	0.78 %
veterinary science		4	0.31 %
agricultural biotechnology		11	0.86 %
other		11	0.86 %
No Answer		1226	96.01 %

please choose the subfield

		Answers	Ratio
psychology		66	5.17 %
economics and business		69	5.4 %
educational sciences		27	2.11 %
sociology		32	2.51 %
law		26	2.04 %
political science		23	1.8 %
social and economic geography		11	0.86 %
media and communications		12	0.94 %
other		28	2.19 %
No Answer		983	76.98 %

please choose the subfield

		Answers	Ratio
history and archaeology		31	2.43 %
languages and literature		31	2.43 %
philosophy, ethics and religion		14	1.1 %
art (i.e. arts, history of arts, performing arts, music)		11	0.86 %
other		14	1.1 %
No Answer		1176	92.09 %

(9) For which type of institution do you conduct research? Multiple answers possible!

		Answers	Ratio
university		1039	81.36 %
public/governmental research institute		332	26 %
other public/governmental organisation		54	4.23 %
private/non-governmental research institute		76	5.95 %
large enterprise (>250 employees)		40	3.13 %
small/medium enterprise (i.e. <250 employees)		32	2.51 %
incubator, start-up, spin-off, or venture capital company		19	1.49 %
non-profit organisation (e.g. civil society organisation, think-tank)		47	3.68 %
other private/non-governmental organisation		17	1.33 %
other		17	1.33 %
No Answer		0	0 %

(10) How much time do you spend on your research on average per week?

		Answers	Ratio
>40 hours		502	39.31 %
30>40 hours		379	29.68 %
20>30 hours		161	12.61 %
10>20 hours		142	11.12 %
<10 hours		93	7.28 %
No Answer		0	0 %

(11) What type of compensation do you receive for your research?

		Answers	Ratio
employment salary		783	61.32 %
research stipend/grant		352	27.56 %
self-funded		95	7.44 %
other		47	3.68 %
No Answer		0	0 %

(12) How many years are left in your current research position?

		Answers	Ratio
permanent contract		237	18.56 %
>5 years		31	2.43 %
4-5 years		36	2.82 %
3-4 years		104	8.14 %
2-3 years		179	14.02 %
1-2 years		337	26.39 %
<1 year		353	27.64 %
No Answer		0	0 %

(13) How much do you know about open science? : open data

		Answers	Ratio
a lot		198	15.51 %
some		548	42.91 %
a little		348	27.25 %
nothing		183	14.33 %
No Answer		0	0 %

(13) How much do you know about open science? : open source

		Answers	Ratio
a lot		304	23.81 %
some		519	40.64 %
a little		302	23.65 %
nothing		152	11.9 %
No Answer		0	0 %

(13) How much do you know about open science? : open notebook

		Answers	Ratio
a lot		43	3.37 %
some		158	12.37 %
a little		329	25.76 %
nothing		747	58.5 %
No Answer		0	0 %

(13) How much do you know about open science? : open access

		Answers	Ratio
a lot		458	35.87 %
some		523	40.96 %
a little		205	16.05 %
nothing		91	7.13 %
No Answer		0	0 %

(13) How much do you know about open science? : open peer review

		Answers	Ratio
a lot		186	14.57 %
some		393	30.78 %
a little		360	28.19 %
nothing		338	26.47 %
No Answer		0	0 %

(13) How much do you know about open science? : open education

		Answers	Ratio
a lot		104	8.14 %
some		354	27.72 %
a little		400	31.32 %
nothing		419	32.81 %
No Answer		0	0 %

(13) How much do you know about open science? : citizen science

		Answers	Ratio
a lot		69	5.4 %
some		253	19.81 %
a little		347	27.17 %
nothing		608	47.61 %
No Answer		0	0 %

(14) Which policy and open science initiatives are you aware of? Multiple answers possible!

		Answers	Ratio
Charter & Code for Researchers (C&C)		152	11.9 %
Human Resources Strategy for Researchers (HRS4R)		121	9.48 %
San Francisco Declaration on Research Assessment (DORA)		129	10.1 %
Principles for Innovative Doctoral Training (IDTP)		65	5.09 %
Responsible Research and Innovation (RRI)		174	13.63 %
Open Innovation, Open Science, Open to the World (the Three Os)		161	12.61 %
European Open Science Cloud (EOSC)		163	12.76 %
Open Access Infrastructure for Research in Europe (OpenAIRE)		215	16.84 %
Facilitate Open Science Training for European Research (FOSTER)		104	8.14 %
Open Access Logo		327	25.61 %
Open Access Button		231	18.09 %
none		552	43.23 %
other		31	2.43 %
No Answer		0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : research and data management

		Answers	Ratio
yes, through training courses		347	27.17 %
yes, through actual practice		680	53.25 %
training courses not sufficient/available		295	23.1 %
not enough/no opportunity for actual practice		267	20.91 %
No Answer		0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : research integrity

		Answers	Ratio
yes, through training courses		315	24.67 %
yes, through actual practice		662	51.84 %
training courses not sufficient/available		288	22.55 %
not enough/no opportunity for actual practice		255	19.97 %
No Answer		0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : research publishing and dissemination

		Answers	Ratio
yes, through training courses		317	24.82 %
yes, through actual practice		864	67.66 %
training courses not sufficient/available		220	17.23 %
not enough/no opportunity for actual practice		135	10.57 %
No Answer		0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : teaching and supervising

	Answers	Ratio
yes, through training courses	348	27.25 %
yes, through actual practice	762	59.67 %
training courses not sufficient/available	241	18.87 %
not enough/no opportunity for actual practice	247	19.34 %
No Answer	0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : collaborating and networking

	Answers	Ratio
yes, through training courses	174	13.63 %
yes, through actual practice	881	68.99 %
training courses not sufficient/available	224	17.54 %
not enough/no opportunity for actual practice	183	14.33 %
No Answer	0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : intellectual property and patenting

	Answers	Ratio
yes, through training courses	335	26.23 %
yes, through actual practice	327	25.61 %
training courses not sufficient/available	367	28.74 %
not enough/no opportunity for actual practice	464	36.34 %
No Answer	0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : fundraising and investment pitching

		Answers	Ratio
yes, through training courses		249	19.5 %
yes, through actual practice		349	27.33 %
training courses not sufficient/available		410	32.11 %
not enough/no opportunity for actual practice		505	39.55 %
No Answer		0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : popularising science for general public

		Answers	Ratio
yes, through training courses		280	21.93 %
yes, through actual practice		639	50.04 %
training courses not sufficient/available		342	26.78 %
not enough/no opportunity for actual practice		290	22.71 %
No Answer		0	0 %

(15) Are you able to develop the skills required for open science? Multiple answers possible! : involving the general public in research

		Answers	Ratio
yes, through training courses		210	16.44 %
yes, through actual practice		459	35.94 %
training courses not sufficient/available		398	31.17 %
not enough/no opportunity for actual practice		430	33.67 %
No Answer		0	0 %

(16) Which incentives related to open science does your institution support? Multiple answers possible!

		Answers	Ratio
open research data		301	23.57 %
open access publishing		581	45.5 %
open access self-archiving		320	25.06 %
open peer reviewing		115	9.01 %
free and open source software		331	25.92 %
dissemination of research via social networks and blogs		343	26.86 %
open educational resources and/or MOOCS (Massive Open Online Courses)		169	13.23 %
conducting research with non-scientific participants (e.g. citizen science projects)		206	16.13 %
shared research infrastructures with other universities		404	31.64 %
shared research infrastructures with citizens and society		130	10.18 %
use of alternative funding mechanisms (e.g. crowd funding. inducement prizes)		74	5.79 %
use of alternative metrics for scientific reputation (e.g. Altmetrics, ResearchGate)		219	17.15 %
none		88	6.89 %
I do not know		415	32.5 %
other		4	0.31 %
No Answer		0	0 %

(17) What support for open science do you think is missing at your institution? Multiple answers possible!

		Answers	Ratio
guidelines/policies for open science		666	52.15 %
general support (e.g. help desk)		554	43.38 %
technical infrastructure		391	30.62 %
specialist support (e.g. data processing, creating a data management plan, publishing in open access)		550	43.07 %
legal advice (e.g. on intellectual property and patenting)		404	31.64 %
online learning modules/tutorials		375	29.37 %
training courses		515	40.33 %
financial support (e.g. for publishing in open access journals)		623	48.79 %
rewards in terms of salary bonus		484	37.9 %
rewards in terms of reputation in your institution		455	35.63 %
incentives in terms of career perspectives		560	43.85 %
incentives in terms of time allocation		435	34.06 %
none		15	1.17 %
I do not know		271	21.22 %
other		8	0.63 %
No Answer		0	0 %

(18) How relevant is data management (e.g. curation, storage, publishing) for your research?

		Answers	Ratio
very relevant		633	49.57 %
relevant		407	31.87 %
neutral		127	9.95 %
somewhat relevant		74	5.79 %
not relevant		36	2.82 %
No Answer		0	0 %

(19) Which support does your institution provide for data management? Multiple answers possible!

		Answers	Ratio
general help desk		245	19.19 %
direct/specialist support		197	15.43 %
legal advice		135	10.57 %
training courses		202	15.82 %
data repository		354	27.72 %
funding		95	7.44 %
none		282	22.08 %
I do not know		388	30.38 %
other		12	0.94 %
No Answer		0	0 %

(20) Have you followed training courses on data management?

		Answers	Ratio
yes, they were useful		161	12.61 %
yes, they were not useful		44	3.45 %
no, I would like to		861	67.42 %
no, I do not need to		211	16.52 %
No Answer		0	0 %

(21) Have you used a data management plan in your research?

		Answers	Ratio
yes, it was required by my institution		67	5.25 %
yes, it was required by my funding body		79	6.19 %
yes, it was required by my institution and funding body		49	3.84 %
yes, it was not required		151	11.82 %
no, I would like to		440	34.46 %
no, I do not need to		145	11.35 %
no, I do not know what a data management plan is		346	27.09 %
No Answer		0	0 %

(22) What type of digital content do you usually create or collect in your data? Multiple answers possible!

		Answers	Ratio
text documents (e.g. DOC, ODF, PDF, TXT)		1143	89.51 %
structured text (e.g. HTML, JSON, TEX, XML)		281	22 %
spreadsheets (e.g. XLS, ODS, CSV, SAS, Stata, SPSS)		848	66.41 %
databases (e.g. MS Access, MySql, Oracle)		241	18.87 %
graphics/images (e.g. JPEG, SVG, PNG, GIF, TIFF)		822	64.37 %
audio (e.g MP3, WAV, AIFF, OGG)		175	13.7 %
video/film (e.g MPEG, AVI, WMV, MP4)		242	18.95 %
source code (e.g. CSS, JavaScript, Java)		262	20.52 %
configuration data (e.g. INI, CONF)		54	4.23 %
data from specialised software		536	41.97 %
software applications		244	19.11 %
other		33	2.58 %
No Answer		0	0 %

(23) How much data storage space does your current research require?

	Answers	Ratio
<50 GB	423	33.12 %
50-100 GB	228	17.85 %
100 GB-1 TB	287	22.47 %
1 TB-1PB	141	11.04 %
>1 PB	13	1.02 %
I do not know	185	14.49 %
No Answer	0	0 %

(24) Where do you store your research data? Multiple answers possible!

	Answers	Ratio
at an external data centre	112	8.77 %
in a cloud service	482	37.74 %
on a server of the institution	445	34.85 %
on a server of the department or institute	248	19.42 %
on a server for my project group	169	13.23 %
on my work computer	827	64.76 %
on my private computer	702	54.97 %
on an external hard drive (also USB drive)	775	60.69 %
on CDs/DVDs	91	7.13 %
on magnetic tapes	9	0.7 %
directly on the machine or instrument	128	10.02 %
other	16	1.25 %
No Answer	0	0 %

(25) Do you provide your research data with metadata (i.e. basic information that describes the data) so that it is accessible for others?

		Answers	Ratio
yes, using standard guidelines (e.g. institutional/disciplinary guidelines)		155	12.14 %
yes, using my own/informal guidelines		350	27.41 %
no, others do this for me		25	1.96 %
no, I would like to		374	29.29 %
no, I do not need to		355	27.8 %
other		18	1.41 %
No Answer		0	0 %

(26) Who is responsible for archiving your research data? Multiple answers possible!

		Answers	Ratio
I myself		1134	88.8 %
project or group manager		160	12.53 %
project or group employee		87	6.81 %
institutional IT centre		103	8.07 %
institutional data repository		72	5.64 %
library		52	4.07 %
external service provider		23	1.8 %
I do not know		96	7.52 %
other		7	0.55 %
No Answer		0	0 %

(27) What will happen to your research data when you leave your institution? Multiple answers possible!

	Answers	Ratio
data will remain at the institution	666	52.15 %
I will take my data with me	711	55.68 %
data will be transferred to a third party	55	4.31 %
data will be deleted	68	5.32 %
I do not know	355	27.8 %
other	21	1.64 %
No Answer	0	0 %

(28) To whom do you usually grant access to your research data? Multiple answers possible!

	Answers	Ratio
my data is open to everyone	183	14.33 %
my specific scientific community	210	16.44 %
members of my institution	252	19.73 %
research project/group members	804	62.96 %
interested persons by request	570	44.64 %
I follow guidelines from my funder	189	14.8 %
my data is kept private	232	18.17 %
other	27	2.11 %
No Answer	0	0 %

(29) How can others gain access to your research data? Multiple answers possible!

		Answers	Ratio
via a data repository		267	20.91 %
as supplementary material for publications		366	28.66 %
via my personal or institutional website		206	16.13 %
via remote server or share drives		194	15.19 %
via cloud applications (e.g. Dropbox, Google Docs)		352	27.56 %
via physical disks, USB, and/or email		495	38.76 %
not at all		237	18.56 %
other		55	4.31 %
No Answer		0	0 %

(30) What type(s) of user agreements have you put in place for access to your data? Multiple answers possible!

		Answers	Ratio
open content licenses (e.g. Creative Commons License, General Public License)		209	16.37 %
individual license agreements		94	7.36 %
cooperation agreements		127	9.95 %
policies of the data repository where data resides		134	10.49 %
none		527	41.27 %
I do not know		378	29.6 %
other		12	0.94 %
No Answer		0	0 %

(31) What would motivate you to openly share your research data? : recognition within the general public

		Answers	Ratio
very important		192	15.04 %
important		466	36.49 %
neutral		377	29.52 %
not very important		158	12.37 %
not important at all		84	6.58 %
No Answer		0	0 %

(31) What would motivate you to openly share your research data? : recognition within the scientific community

		Answers	Ratio
very important		556	43.54 %
important		507	39.7 %
neutral		128	10.02 %
not very important		51	3.99 %
not important at all		35	2.74 %
No Answer		0	0 %

(31) What would motivate you to openly share your research data? : recognition in project and/or career evaluations

	Answers	Ratio
very important	540	42.29 %
important	493	38.61 %
neutral	155	12.14 %
not very important	56	4.39 %
not important at all	33	2.58 %
No Answer	0	0 %

(31) What would motivate you to openly share your research data? : increased visibility and impact of my research

	Answers	Ratio
very important	676	52.94 %
important	465	36.41 %
neutral	98	7.67 %
not very important	18	1.41 %
not important at all	20	1.57 %
No Answer	0	0 %

(31) What would motivate you to openly share your research data? : possibility for my data to be cited

		Answers	Ratio
very important		625	48.94 %
important		456	35.71 %
neutral		133	10.42 %
not very important		37	2.9 %
not important at all		26	2.04 %
No Answer		0	0 %

(31) What would motivate you to openly share your research data? : new contacts and/or opportunities for cooperation

		Answers	Ratio
very important		619	48.47 %
important		477	37.35 %
neutral		143	11.2 %
not very important		21	1.64 %
not important at all		17	1.33 %
No Answer		0	0 %

(31) What would motivate you to openly share your research data? : financial support for open sharing (e.g. bonus, expense allowance)

		Answers	Ratio
very important		466	36.49 %
important		388	30.38 %
neutral		272	21.3 %
not very important		91	7.13 %
not important at all		60	4.7 %
No Answer		0	0 %

(31) What would motivate you to openly share your research data? : technical support in making data accessible

		Answers	Ratio
very important		340	26.62 %
important		480	37.59 %
neutral		307	24.04 %
not very important		101	7.91 %
not important at all		49	3.84 %
No Answer		0	0 %

(31) What would motivate you to openly share your research data? : standards for accountability and appropriate use of data

		Answers	Ratio
very important		407	31.87 %
important		426	33.36 %
neutral		302	23.65 %
not very important		93	7.28 %
not important at all		49	3.84 %
No Answer		0	0 %

(31) What would motivate you to openly share your research data? : other

		Answers	Ratio
very important		42	3.29 %
important		5	0.39 %
neutral		43	3.37 %
not very important		3	0.23 %
not important at all		20	1.57 %
No Answer		1164	91.15 %

(32) What would keep you from sharing your research data with others? Multiple answers possible!

	Answers	Ratio
personal data protection and confidentiality	790	61.86 %
legal restrictions (e.g. copyright, patent law, trademark)	715	55.99 %
financial costs	417	32.65 %
lack of skills	303	23.73 %
increased time and effort required	525	41.11 %
lack of clear advantages in sharing data	460	36.02 %
increased competition in the 'publish or perish' game	501	39.23 %
risk of misinterpretation and/or falsification of data	481	37.67 %
economic competitiveness/undesired commercial use	252	19.73 %
lack of institutional guidelines for data sharing	436	34.14 %
missing data standards and established processes	276	21.61 %
use of rare data formats	96	7.52 %
nothing	57	4.46 %
other	27	2.11 %
No Answer	0	0 %

Note there are no results for Q33-35 as they were open questions.

(36) Have you received training courses on open access publishing?

		Answers	Ratio
yes, they were useful		109	8.54 %
yes, they were not useful		43	3.37 %
no, I would like to		886	69.38 %
no, I do not need to		239	18.72 %
No Answer		0	0 %

(37) Does your institution have any guidelines regarding open access publishing?

		Answers	Ratio
yes, institutional guidelines		194	15.19 %
yes, informal guidelines (i.e. not formalised but apparent in institutional practices)		122	9.55 %
no		332	26 %
I do not know		621	48.63 %
other		8	0.63 %
No Answer		0	0 %

(38) What type of funding supporting publishing in open access are you aware of? Multiple answers possible!

		Answers	Ratio
general institution budget		364	28.5 %
project-based institutional funding		406	31.79 %
cooperative funding across institutions		93	7.28 %
regional funding		69	5.4 %
national funding		225	17.62 %
European funding (e.g. Horizon 2020)		437	34.22 %
international/global funding		75	5.87 %
other public funding		62	4.86 %
private funding		108	8.46 %
public-private funding		42	3.29 %
none		470	36.81 %
other		23	1.8 %
No Answer		0	0 %

(39) Does your current project funding come with guidelines for publishing in open access?

		Answers	Ratio
yes, there are strict guidelines		102	7.99 %
yes, there are suggested guidelines		167	13.08 %
no, there should be guidelines		374	29.29 %
no, there is no need for guidelines		195	15.27 %
I do not know		439	34.38 %
No Answer		0	0 %

(40) Which steps should be taken to promote and improve open access publishing? Multiple answers possible!

		Answers	Ratio
provide the infrastructure and support		715	55.99 %
make it compulsory for researchers to publish in open access journals/textbooks		464	36.34 %
make it compulsory for researchers to deposit their publications in repositories/archives		456	35.71 %
link successful open access publications to the performance evaluation of researchers		501	39.23 %
funding from the institution to publish open access		801	62.73 %
raise awareness on open access publishing		642	50.27 %
negotiate with publishers to reduce author publishing charges (APCs)		716	56.07 %
I do not know		130	10.18 %
other		32	2.51 %
No Answer		0	0 %

(41) What would motivate you to make more of your publications available on open access? : providing free access to a wide audience

		Answers	Ratio
very important		674	52.78 %
important		427	33.44 %
neutral		127	9.95 %
not very important		34	2.66 %
not important at all		15	1.17 %
No Answer		0	0 %

(41) What would motivate you to make more of your publications available on open access? : maximising the visibility of research

		Answers	Ratio
very important		764	59.83 %
important		404	31.64 %
neutral		84	6.58 %
not very important		16	1.25 %
not important at all		9	0.7 %
No Answer		0	0 %

(41) What would motivate you to make more of your publications available on open access? : increasing the number of citations

		Answers	Ratio
very important		605	47.38 %
important		434	33.99 %
neutral		173	13.55 %
not very important		47	3.68 %
not important at all		18	1.41 %
No Answer		0	0 %

(41) What would motivate you to make more of your publications available on open access? : enabling the re-use of research data

	Answers	Ratio
very important	448	35.08 %
important	487	38.14 %
neutral	262	20.52 %
not very important	62	4.86 %
not important at all	18	1.41 %
No Answer	0	0 %

(41) What would motivate you to make more of your publications available on open access? : reduced publishing costs in journals

	Answers	Ratio
very important	636	49.8 %
important	375	29.37 %
neutral	197	15.43 %
not very important	49	3.84 %
not important at all	20	1.57 %
No Answer	0	0 %

(41) What would motivate you to make more of your publications available on open access? : promoting the work of researchers

		Answers	Ratio
very important		576	45.11 %
important		516	40.41 %
neutral		157	12.29 %
not very important		19	1.49 %
not important at all		9	0.7 %
No Answer		0	0 %

(41) What would motivate you to make more of your publications available on open access? : better research assessment and monitoring

		Answers	Ratio
very important		469	36.73 %
important		504	39.47 %
neutral		253	19.81 %
not very important		34	2.66 %
not important at all		17	1.33 %
No Answer		0	0 %

(41) What would motivate you to make more of your publications available on open access? : better career development and chances of promotion

		Answers	Ratio
very important		535	41.9 %
important		417	32.65 %
neutral		253	19.81 %
not very important		52	4.07 %
not important at all		20	1.57 %
No Answer		0	0 %

(41) What would motivate you to make more of your publications available on open access? : recognition of time spent on article publication

		Answers	Ratio
very important		446	34.93 %
important		419	32.81 %
neutral		316	24.75 %
not very important		61	4.78 %
not important at all		35	2.74 %
No Answer		0	0 %

(41) What would motivate you to make more of your publications available on open access? : other

	Answers	Ratio
very important	22	1.72 %
important	3	0.23 %
neutral	15	1.17 %
not very important	2	0.16 %
not important at all	7	0.55 %
No Answer	1228	96.16 %

(42) The impact factor/quality of a journal is more important for me than if it is open access.

	Answers	Ratio
strongly agree	429	33.59 %
agree	469	36.73 %
neutral	246	19.26 %
disagree	75	5.87 %
strongly disagree	58	4.54 %
No Answer	0	0 %

(43) I would do a PhD again if I had the choice. :
In my research field

		Answers	Ratio
strongly agree		467	36.57 %
agree		384	30.07 %
neutral		202	15.82 %
disagree		130	10.18 %
strongly disagree		94	7.36 %
No Answer		0	0 %

(43) I would do a PhD again if I had the choice. :
In another research field

		Answers	Ratio
strongly agree		198	15.51 %
agree		383	29.99 %
neutral		349	27.33 %
disagree		214	16.76 %
strongly disagree		133	10.42 %
No Answer		0	0 %

(44) I would like to work/continue working as a researcher.

		Answers	Ratio
strongly agree		645	50.51 %
agree		433	33.91 %
neutral		142	11.12 %
disagree		46	3.6 %
strongly disagree		11	0.86 %
No Answer		0	0 %

(45) Standard PhD training in my research field only provides preparation for an academic career.

		Answers	Ratio
strongly agree		290	22.71 %
agree		470	36.81 %
neutral		271	21.22 %
disagree		203	15.9 %
strongly disagree		43	3.37 %
No Answer		0	0 %

(46) I would like to work/continue working in academia (e.g. at a university or research institute).

		Answers	Ratio
strongly agree		552	43.23 %
agree		402	31.48 %
neutral		212	16.6 %
disagree		84	6.58 %
strongly disagree		27	2.11 %
No Answer		0	0 %

(47) Standard PhD training in my research field also provides preparation for a non-academic career.

		Answers	Ratio
strongly agree		86	6.73 %
agree		343	26.86 %
neutral		315	24.67 %
disagree		358	28.03 %
strongly disagree		175	13.7 %
No Answer		0	0 %

(48) A PhD in my research field is attractive for non-academic employers.

		Answers	Ratio
strongly agree		131	10.26 %
agree		386	30.23 %
neutral		368	28.82 %
disagree		277	21.69 %
strongly disagree		115	9.01 %
No Answer		0	0 %

(49) I would like to work/continue working outside of academia (e.g. in the public or private sector).

		Answers	Ratio
strongly agree		132	10.34 %
agree		431	33.75 %
neutral		440	34.46 %
disagree		211	16.52 %
strongly disagree		63	4.93 %
No Answer		0	0 %

(50) I would like to combine working both inside and outside academia.

		Answers	Ratio
strongly agree		352	27.56 %
agree		494	38.68 %
neutral		284	22.24 %
disagree		116	9.08 %
strongly disagree		31	2.43 %
No Answer		0	0 %

(51) It is clear to me what my future career options are in/after my current position.

		Answers	Ratio
strongly agree		158	12.37 %
agree		371	29.05 %
neutral		287	22.47 %
disagree		279	21.85 %
strongly disagree		182	14.25 %
No Answer		0	0 %

(52) In which sectors would you be interested in working? :
industry and private sector

		Answers	Ratio
very interested		287	22.47 %
interested		455	35.63 %
neutral		218	17.07 %
somewhat interested		148	11.59 %
not interested		169	13.23 %
No Answer		0	0 %

(52) In which sectors would you be interested in working? :
government

		Answers	Ratio
very interested		247	19.34 %
interested		476	37.27 %
neutral		240	18.79 %
somewhat interested		173	13.55 %
not interested		141	11.04 %
No Answer		0	0 %

(52) In which sectors would you be interested in working? : hospital

		Answers	Ratio
very interested		98	7.67 %
interested		166	13 %
neutral		215	16.84 %
somewhat interested		168	13.16 %
not interested		630	49.33 %
No Answer		0	0 %

(52) In which sectors would you be interested in working? : museum

		Answers	Ratio
very interested		73	5.72 %
interested		154	12.06 %
neutral		183	14.33 %
somewhat interested		185	14.49 %
not interested		682	53.41 %
No Answer		0	0 %

(52) In which sectors would you be interested in working? : academic or public research institution

	Answers	Ratio
very interested	746	58.42 %
interested	378	29.6 %
neutral	86	6.73 %
somewhat interested	46	3.6 %
not interested	21	1.64 %
No Answer	0	0 %

(52) In which sectors would you be interested in working? : higher non-university education (e.g. VET)

	Answers	Ratio
very interested	159	12.45 %
interested	357	27.96 %
neutral	335	26.23 %
somewhat interested	143	11.2 %
not interested	283	22.16 %
No Answer	0	0 %

(52) In which sectors would you be interested in working? : primary or secondary education

		Answers	Ratio
very interested		35	2.74 %
interested		176	13.78 %
neutral		233	18.25 %
somewhat interested		232	18.17 %
not interested		601	47.06 %
No Answer		0	0 %

(52) In which sectors would you be interested in working? : non-profit sector (e.g. NGOs)

		Answers	Ratio
very interested		148	11.59 %
interested		377	29.52 %
neutral		277	21.69 %
somewhat interested		222	17.38 %
not interested		253	19.81 %
No Answer		0	0 %

(52) In which sectors would you be interested in working? : be self-employed (with or without staff)

	Answers	Ratio
very interested	167	13.08 %
interested	299	23.41 %
neutral	270	21.14 %
somewhat interested	185	14.49 %
not interested	356	27.88 %
No Answer	0	0 %

(52) In which sectors would you be interested in working? : other

	Answers	Ratio
very interested	7	0.55 %
interested	3	0.23 %
neutral	10	0.78 %
somewhat interested	0	0 %
not interested	21	1.64 %
No Answer	1236	96.79 %

(53) With which sectors have you cooperated on your research in your current position? Multiple answers possible!

	Answers	Ratio
industry and private sector	585	45.81 %
government	434	33.99 %
hospital	225	17.62 %
museum	108	8.46 %
another academic or public research institution	920	72.04 %
higher non-university education	152	11.9 %
schools outside of higher education (e.g. secondary education)	129	10.1 %
non-profit sector (e.g. NGOs)	230	18.01 %
none	133	10.42 %
other	14	1.1 %
No Answer	0	0 %

(54) Have you created a company during your current position?

	Answers	Ratio
yes, a spin-off (within institution)	22	1.72 %
yes, a start-up (outside of institution)	53	4.15 %
yes, a spin-off and a start-up	6	0.47 %
no, I would like to	391	30.62 %
no, I do not need to	805	63.04 %
No Answer	0	0 %

(55) Are you currently searching for new employment?

	Answers	Ratio
yes, I am actively searching	181	14.17 %
yes, I search from time to time	306	23.96 %
no, I will search towards the end of my current position	324	25.37 %
no, I will search after my current position	129	10.1 %
no, I am happy with my current position	312	24.43 %
other	25	1.96 %
No Answer	0	0 %

(56) My institution provides adequate career development. :
via a career development plan

	Answers	Ratio
strongly agree	44	3.45 %
agree	192	15.04 %
neutral	317	24.82 %
disagree	359	28.11 %
strongly disagree	365	28.58 %
No Answer	0	0 %

(56) My institution provides adequate career development. : via training courses

		Answers	Ratio
strongly agree		61	4.78 %
agree		301	23.57 %
neutral		326	25.53 %
disagree		300	23.49 %
strongly disagree		289	22.63 %
No Answer		0	0 %

**(56) My institution provides adequate career development. :
via career counselling**

		Answers	Ratio
strongly agree		39	3.05 %
agree		161	12.61 %
neutral		321	25.14 %
disagree		367	28.74 %
strongly disagree		389	30.46 %
No Answer		0	0 %

(56) My institution provides adequate career development. : via career mentoring

		Answers	Ratio
strongly agree		39	3.05 %
agree		188	14.72 %
neutral		327	25.61 %
disagree		342	26.78 %
strongly disagree		381	29.84 %
No Answer		0	0 %

(56) My institution provides adequate career development. : via contact with future employers

		Answers	Ratio
strongly agree		39	3.05 %
agree		143	11.2 %
neutral		358	28.03 %
disagree		333	26.08 %
strongly disagree		404	31.64 %
No Answer		0	0 %

Is it alright if we share your data anonymously with national/European researcher representatives?

		Answers	Ratio
yes		1248	97.73 %
no		29	2.27 %
No Answer		0	0 %

Is it alright if we publish your data anonymously on the Internet to openly share the survey results?

		Answers	Ratio
yes		1216	95.22 %
no		61	4.78 %
No Answer		0	0 %

APPENDIX 4: REVISED EUROPEAN FRAMEWORK FOR RESEARCHER CAREERS (EFRC)

A structure to classify researchers was developed in the European Commission document, 'Towards a European Framework for Research Careers' (2011).[91] This classification communicates the various characteristics that researchers may have throughout their career and is independent of a particular career path or sector. It identifies characteristics typically required for highly diverse careers in the education, research, public and private sectors. In this appendix we have adapted the desirable skills attributes associated with each category of researcher to include Open Science Skills and optimal training modes and mechanisms.

Researchers at all career stages (R1 to R4) need to be offered opportunities, either through formal courses or through professional practice, to develop the various facets of skills required by Open Science approaches, for example requirements for open access to research data and open access to publications. As the needs of researchers will vary according to their disciplinary requirements and experience, there should be a portfolio of identified training needs as part of their Personal Career Development Plan (PCDP). This is particularly important for researchers at R1 and R2 levels. In addition, these skills have to be continuously developed by researchers along their career trajectories from R1-R4. Usually there is a high concentration on the doctoral training. Other categories of researchers also need continuous training and development. While scientific training forms part of researchers' training throughout their careers (through, for example, conference participation, sabbaticals and specific training courses), the complementary skills imposed by a structural change in science practice, as is the case for Open Science, are not specifically included at this time.

The working group identified a series of skills categories that researchers will need to develop in order to fully participate in an Open Science world. We provide below a more detailed overview of these required skills at all career stages, as well as recommendations for how they can be provided.

In the case of first stage (R1) researchers, it is recommended that mandatory Open Science skills are offered as part of the accredited training of all doctoral candidates. By 'embedded' it is meant that the skills imparted will have a direct and practical application within their disciplinary field (recognizing that significant disciplinary differences apply in Open Science practice). Rather than being just a generic 'add-on' to existing courses, for real engagement it is critical that this type of training is contextualized and is of immediate relevance to their work. It should also be recognised that many of these skills will also be acquired as part of the research process. It is therefore important in this case that this is taken into account and recognised. This approach is strongly supported by the responses to our survey of researchers: researchers perceive the opportunities for skills development as better through actual practice than through training courses. Problem-based learning (PBL) modes and implementation through practical course work and Open Science portfolio creation are recommended for this approach. Blended learning via online courses and mentoring could also work but only in so far that the embedded approach is applied. Doctoral candidates should see Open Science skills as a scalable and marketable life skill and part of the

91 https://cdn5.euraxess.org/sites/default/files/policy_library/towards_a_european_framework_for_research_careers_final.pdf

toolkit and expertise level expected of any research professional. Therefore, this training should be integrated with researcher career development programmes. Researchers at this level should also be aware of European recruitment benefits associated with their Open Science skills.

For recognized (R2) researchers at the postdoctoral level or equivalent, it is recommended that the mandatory Open Science skills imparted at the postgraduate (R1) level are further developed and enhanced by reinforcement of the basic Open Science skills with deeper emphasis on open access research dissemination and data management, as well as the addition of training in research impact, innovation, and research evaluation (introductory level) Again, relevance is key to researcher engagement. Therefore, structured training should be offered within the researcher’s disciplinary context. Accredited professional development will take the place of the classroom for these researchers, along with Open Science mentoring from colleagues. Recognized Open Science leadership skills training should be available to researchers at this level to allow them to mentor and lead in this area. Researchers at this level should also be aware of European recruitment, institutional promotional benefits and funder recognition associated with Open Science skills.

<table>
<tr><td colspan="2">First Stage Researcher (R1)</td></tr>
<tr><td colspan="2">Includes individuals doing research under supervision in industry, research institutes or universities. It includes doctoral candidates. Researchers with this profile will:

• Carry out research under supervision.

• Have the ambition to develop knowledge of research methodologies and discipline.

• Have demonstrated a good understanding of a field of study.

• Have demonstrated the ability to produce data under supervision.

• Be capable of critical analysis, evaluation and synthesis of new and complex ideas.

• Be able to explain the outcome of research and value thereof to research colleagues.</td></tr>
<tr><td rowspan="2">Desirable competences

• Develops integrated language, communication and environment skills, especially in an international context.</td><td>Open Science competences:
Research integrity/ethics, Information literacy, open access, publishing/dissemination, Data Management Plans etc.</td></tr>
<tr><td>Optimal training/learning modes & incentives.

Formal, structured, learning, standardised, accredited and badged. Use of independent and active learning styles: hands-on, applied, PBL.

Mentoring by senior researchers

Integrated with Researcher Career Development.</td></tr>
</table>

<table>
<tr><td colspan="2">Recognised Researcher (R2)</td></tr>
<tr><td colspan="2">• Doctorate degree (PhD) holders who have not yet established a significant level of independence;

• Researchers with an equivalent level of experience and competence.

Necessary competences (All competences of ‘First Stage Researcher’ plus:)

• Has demonstrated a systematic understanding of a field of study and mastery of research associated with that field.

• Has demonstrated the ability to conceive, design, implement and adapt a substantial programme of research with integrity.

• Has made a contribution through original research that extends the frontier of knowledge.

• Demonstrates critical analysis, evaluation and synthesis of new and complex ideas.

• Can communicate with their peers - be able to explain the outcome of their research and value thereof to the research community.

• Takes ownership for and manages own career progression.

• Co-authors papers at workshop and conferences.</td></tr>
<tr><td rowspan="2">Desirable competences

• Understands the agenda of industry and other related employment sectors

• Understands the value of their research work in the context of products and services from industry & related employment sectors

• Can communicate with the wider community, and with society generally

• Can be expected to promote technological, social or cultural advancement in a knowledge based society

• Can mentor First Stage Researchers</td><td>Open Science competences:

as per R1 plus skills for research impact, innovation and research evaluation (introductory).</td></tr>
<tr><td>Optimal training/learning modes & incentives.

Structured, accredited professional development training;

Mentoring, rewards & funder incentives.</td></tr>
</table>

Established Researcher (R3)	
Includes: Researchers who have developed a level of independence. **Necessary competences** All necessary and most desirable competences of 'Recognised Researcher' plus: • Has an established reputation based on research excellence in their field • Makes a positive contribution to the development of knowledge, research and development through co-operations and collaborations. • Identifies research problems and opportunities within their area of expertise. • Identifies appropriate research methodologies and approaches. • Conducts research independently which advances a research agenda. • Can take the lead in executing collaborative research projects in cooperation with colleagues and project partners. • Publishes papers as lead author, organises workshop or conference sessions.	
Desirable competences • Establishes collaborative relationships with relevant industry research or development groups. • Communicates their research effectively to the research community and wider society. • Is innovative in their approach to research. • Can form research consortia and secure research funding / budgets / resources from research councils or industry. • Is committed to professional development of their own career and acts as mentor for others.	**Open Science competences:** as per R2 plus impact, innovation, research evaluation (intermediate to advanced levels), funding proposals, research management. **Optimal training/learning modes & incentives.** Structured, accredited professional development training; Mentoring, rewards & funder incentives.

For Established Researchers (R3), it is recommended that the mandatory Open Science skills imparted at the postgraduate (R1) and postdoctoral (R2) level are further developed and enhanced by reinforcement of the basic Open Science skills on open access research dissemination and data management. In addition, there should be a greater additional emphasis on research impact tracking and reporting, innovation, and research evaluation at intermediate to advanced levels (relevant research metrics and altmetrics) as well as on funding proposal and compliance with funder policies. Delivery is recommended through accredited professional training courses supported by peer mentoring. Recognized Open Science leadership skills training should be also be available to researchers at this level to allow them to mentor and lead in this area. Researchers at this level should be aware of European recruitment, institutional promotional benefits and funder recognition associated with Open Science skills. The implications of failure to comply with Open Science requirements at the funder and institutional levels should be clear to researchers at this level along with a knowledge of how to avail of the supporting infrastructure to save their time, maximize impact and rewards and make Open Science an accepted and easy part of their research work routine.

Finally, all leading researchers (R4) should also be Open Science leaders – in the lab (or equivalent for humanities and social sciences), as Principal Investigators and at the policymaking table. It is recommended that the mandatory Open Science skills imparted at the postgraduate (R1), postdoctoral (R2) and established researcher (R3) levels are offered to Leading Researchers if they have not already attained these skills as part of their previous professional training. A professionally accredited 'fast-track' course should be available in these instances. This should be enhanced as part of institutional senior management training programs to include impact monitoring and reporting, innovation, advanced research evaluation, Open Science in funding proposals, Open Science in research project reporting, and communication and engagement with policy-makers and media. Open Science leadership accreditation should be integrated in prestigious top-level leadership courses (such as those often engaged in externally with senior peers from other institutions/countries). Accredited Open Science leadership attainment should be considered *de rigueur* for Leading Researchers and should be expected by funders, along with a clear personal Open Science track record for all Principal Investigators qualifying for research grants. R4 researchers may also to some extent have the power to influence their organisation's policy on open science. How to present the advantages and the implementation modalities of an OS policy at institutional level could also be one of the areas included with the leadership skills for this category of researchers.

A parallel system of recognized, standardized structured skills training should be available to staff in libraries, IT departments, research offices and administrative areas with accredited leadership skills courses available for institutional senior management who are responsible for the provision of crucial support through technical solutions and trained support staff. This should complement the recommendations made in this report for specialist Open Science information professionals (specialist librarians and data stewards) and provide the necessary personnel required to support researchers (R1-R4) to successfully and optimally practice Open Science.

<table>
<tr><td colspan="2">Leading Researcher (R4)</td></tr>
<tr><td colspan="2">Includes: Researchers who have developed a level of independence.

Necessary competences (All necessary and most desirable competences of ‘Established Researcher’ plus:)

• Has an international reputation based on research excellence in their field

• Demonstrates critical judgment in the identification and execution of research activities.

• Makes a substantial contribution (breakthroughs) to their research field or spanning multiple areas.

• Develops a strategic vision on the future of the research field.

• Recognises the broader implications and applications of their research.

• Publishes and presents influential papers and books, serves on workshop and conference organising committees and delivers invited talks.</td></tr>
<tr><td rowspan="2">Desirable competences

• Is an expert at managing and leading research projects.

• Is skilled at managing and developing others.

• Has a proven record in securing significant research funding / budgets / resources.</td><td>Open Science competences:

as per R3 plus impact monitoring and reporting, innovation, research evaluation level 3, funding proposals, research project reporting; communication and engagement with policy-makers, media. Open Science leadership.</td></tr>
<tr><td>Optimal training/learning modes & incentives:

Integrated into accredited institutional senior management training programmes + prestigious external leadership courses.
Open Science Leadership accreditation required by funders for all funded PIs, plus evidence of open access track record.</td></tr>
</table>

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The EU Open Data Portal (http://data.europa.eu/euodp/en/data) provides access to datasets from the EU. Data can be downloaded and reused for free, both for commercial and non-commercial purposes.

The Expert Group on Education and Skills under Open Science presents in this report a detailed study of the skills and competencies researchers need to practise Open Science. The report provides the results of a survey amongst researchers in Europe on their perceptions on Open Science policies and practices and then focuses on the specific skills researchers need for Open Science. The report concludes with policy recommendations for stakeholders at a European, national, and institutional level to raise awareness, train, support, and encourage researchers in Open Science.

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