



# **Providing researchers with the skills and competencies they need to practise Open Science**

Open Science Skills Working Group Report

Written by the Working Group on Education and Skills under Open Science  
July – 2017

*Research and  
Innovation*

## **Providing researchers with the skills and competencies they need to practise Open Science**

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Open Science Skills Working Group Report

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## Table of Contents

EXECUTIVE SUMMARY	4
1. INTRODUCTION	5
2. OPEN SCIENCE FOR RESEARCHERS: PERSPECTIVES AND GOOD PRACTICES	7
2.1. Survey on Open Science and Career Development for Researchers	7
2.2. Framing Open Science	8
2.3. Professional Development for Open Science	10
2.4. Supporting Open Science	11
2.5. Practising Open Science	12
2.6. Accessing Open Science	14
2.7. Rewarding Open Science	15
3. OPEN SCIENCE SKILLS FOR RESEARCHERS	16
3.1. Categories of Open Science Skills	17
3.2. The Current Open Science Skills Provision Landscape	19
4. ENGAGING RESEARCHERS AT ALL LEVELS IN OPEN SCIENCE	20
4.1. Engaging Researchers in Open Science - Perceptions and Reality	20
4.2. The European Skills, Qualifications and Competencies Landscape	22
4.3. A European Skills and Qualifications Matrix for Open Science	22
5. OPEN SCIENCE EMBEDDED IN ERA POLICY	25
5.1. ERA Policy and alignment with the Open Science Agenda	25
5.2. The Human Resources Strategy for Researchers (HRS4R)	25
5.3. The Doctorate and the Innovative Doctoral Training Principles (IDTP)	25
6. CONCLUSION AND RECOMMENDATIONS	26
6.1. Recommendation 1: Open Science Policy	28
6.2. Recommendation 2: Guidelines to Implement Open Science	28
6.3. Recommendation 3: Raising Awareness of Open Science	29
6.4. Recommendation 4: Training Researchers for Open Science	29
6.5. Recommendation 5: Providing Support for Open Science	30
6.6. Recommendation 6: Career Development for Open Science	30
7. ADDITIONAL READING	30

## 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 researcher 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'<sup>1</sup> worked with a specific mandate to propose recommendations to ensure that researchers in Europe have appropriate skills and competences to practice Open Science<sup>2</sup>. 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),<sup>3</sup> and the Innovative Doctoral Training Principles (IDTP).<sup>4</sup> 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).<sup>5</sup>

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<sup>1</sup> See appendix 1 for details.

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

<sup>3</sup> <https://euraxess.ec.europa.eu/jobs/hrs4r>

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

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

# 1. INTRODUCTION

*“Researchers at all career stages<sup>6</sup> 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<sup>7</sup>*

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.<sup>8</sup> 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).<sup>9</sup>

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,<sup>10</sup> 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.

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

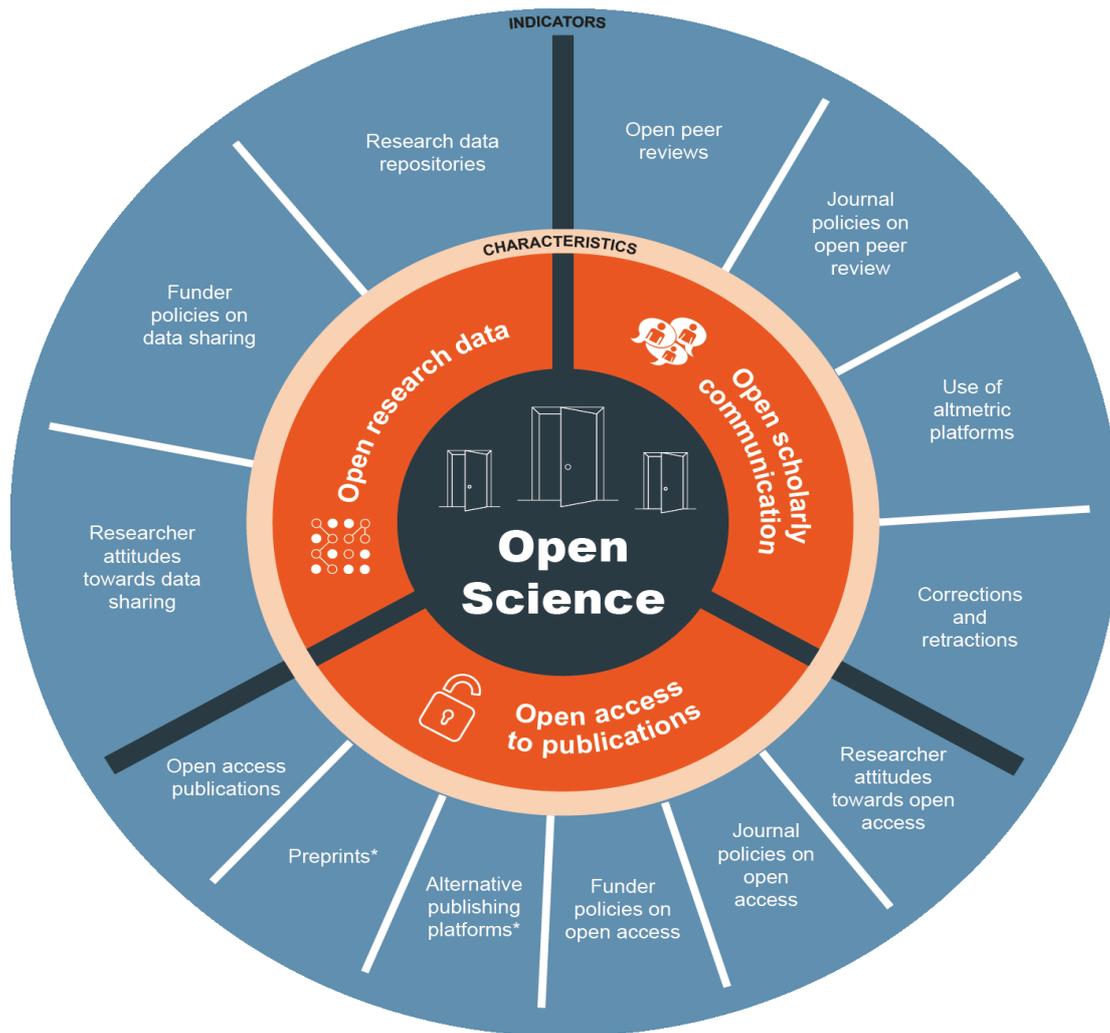
<sup>7</sup> <https://euraxess.ec.europa.eu/jobs/charter/european-charter>

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

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

<sup>10</sup> [https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-1062784\\_en](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.<sup>11</sup>



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,<sup>12</sup> 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.

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

<sup>12</sup> <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<sup>13</sup> 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.<sup>14</sup>

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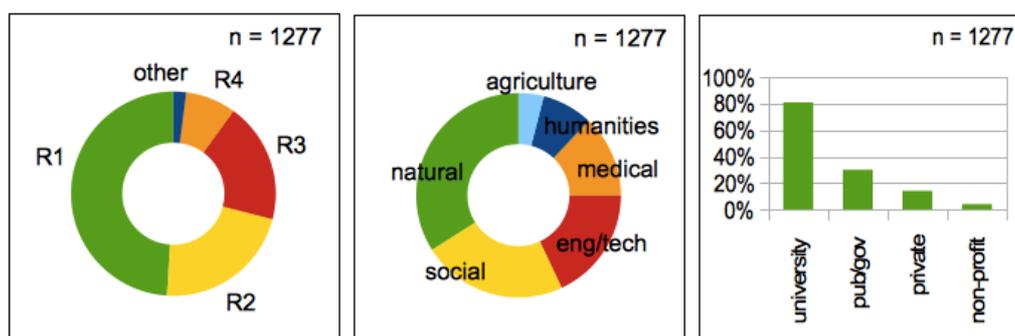
<sup>13</sup> We are further grateful to several policy officers at the European Commission, members of Eurodoc, and other researchers who commented on and tested the survey before release.

<sup>14</sup> <https://ec.europa.eu/eusurvey/runner/OSCDSurvey2017>

The survey drew on previous surveys on Open Science and career development for researchers.<sup>15</sup> 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.<sup>16</sup> Slightly more researchers identify as female than male.<sup>17</sup> 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).<sup>18</sup> 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.<sup>19</sup>

<sup>15</sup> 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](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\\_bCyrIKSxU92LMMD](https://leidenuniv.eu.qualtrics.com/jfe/form/SV_bCyrIKSxU92LMMD).

<sup>16</sup> 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](https://www.elsevier.com/_data/assets/pdf_file/0004/281920/Open-data-report.pdf).

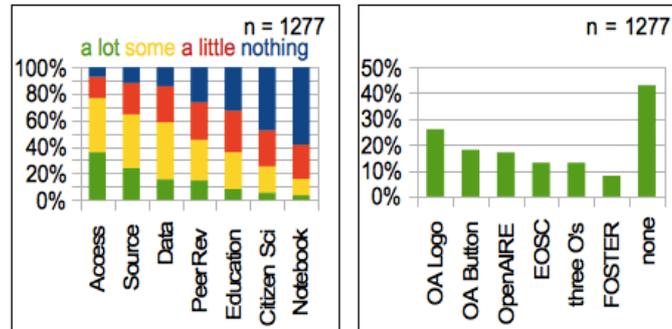
<sup>17</sup> See the appendix for the survey questions and a general summary of the results (excluding the results for Q33-35 which were open questions).

<sup>18</sup> 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.

<sup>19</sup> <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,<sup>20</sup> Open Innovation,<sup>21</sup> Open Science,<sup>22</sup> Open to the World,<sup>23</sup> and the European Open Science Cloud (EOSC).<sup>24</sup> They are more aware of the OpenAire<sup>25</sup> project and the Open Access Button,<sup>26</sup> with the Open Access Logo being the most well-known. Additionally, both the Human Resources Strategy for Researchers (HRS4R)<sup>27</sup> and the Charter & Code for Researchers (C&C)<sup>28</sup> 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.<sup>29</sup> 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.<sup>30</sup>

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

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>

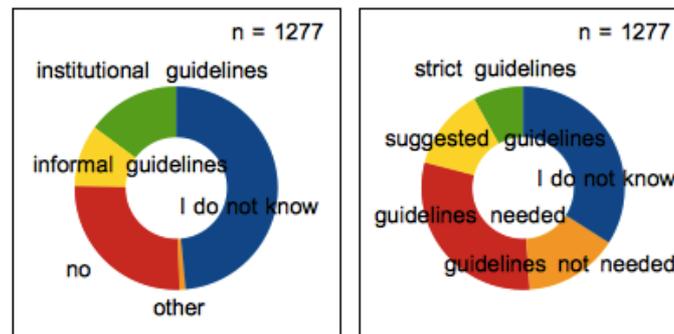
29 <https://sparcopen.org/>

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<sup>33</sup> and a website<sup>34</sup> 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.<sup>35</sup> 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.<sup>36</sup> The two main courses focus on publishing in Open Access and research data management.

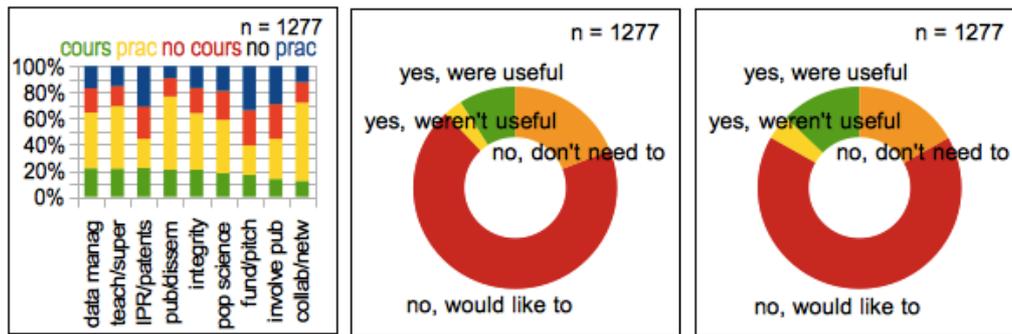
33 <https://repository.tudelft.nl/islandora/object/uuid:9e9fa82e-06c1-4d0d-9e20-5620259a6c65?collection=research>

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

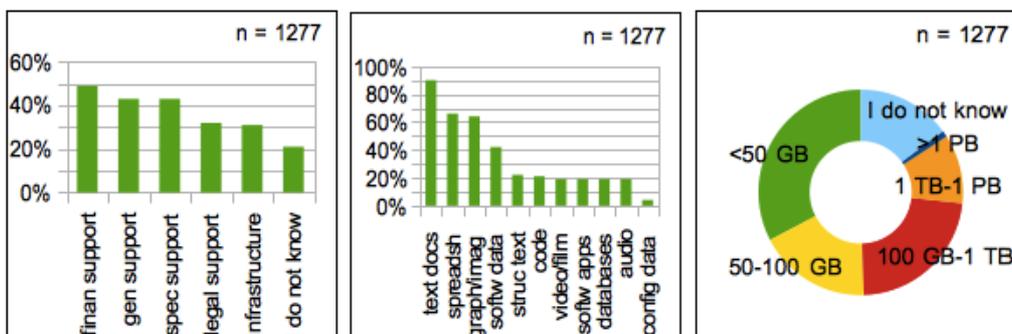
It is not enough to simply encourage and train researchers to do Open Science. Supporting Open Science by providing a digital and support infrastructure for researchers is crucial to maintaining momentum in initial Open Science advances. Support for Open Science is, however, generally lacking in institutions 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.<sup>37</sup> 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.<sup>38</sup> 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.



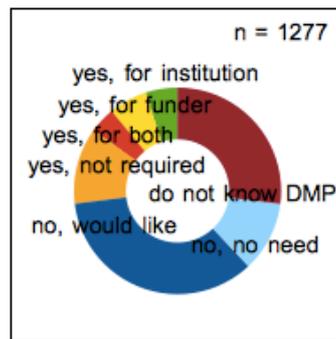
37 <https://www.openaire.eu/>

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,<sup>39</sup> 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.<sup>40</sup> 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.<sup>41</sup> The DCC provides information and support on DMPs along with a web-based tool DMPonline.<sup>42</sup>

**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](https://ec.europa.eu/research/press/2016/pdf/opendata-infographic_072016.pdf)

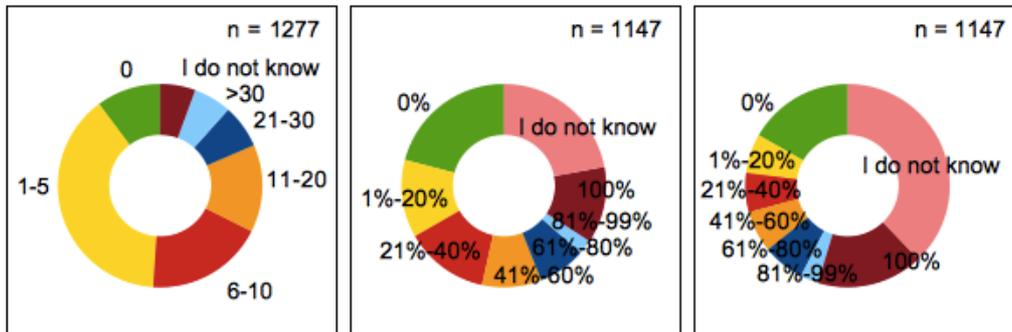
40 [http://ec.europa.eu/research/participants/data/ref/h2020/grants\\_manual/hi/oa\\_pilot/h2020-hi-oa-data-mgt\\_en.pdf](http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf)

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.<sup>43</sup> Member organisations include LingOA, MathOA, and PsyOA.

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



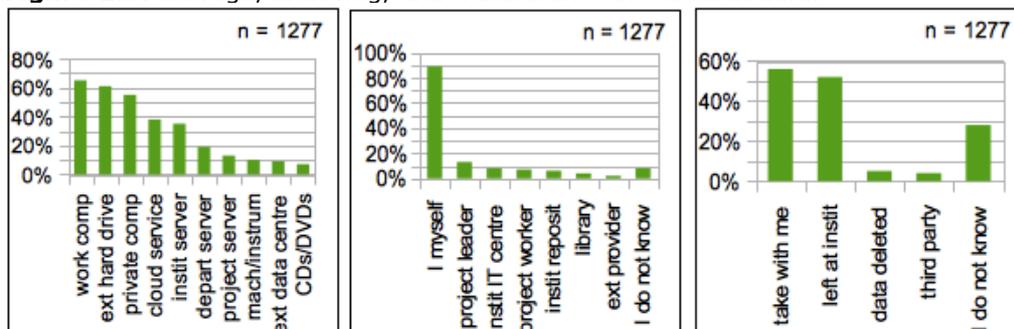
Once research data have been created, they need to be stored somewhere safely, a topic addressed by the European Open Science Cloud WG under the Open Science Policy Platform (OSPP).<sup>44</sup> Many researchers store their data in more than one place as in Figure 2.8. This is most often on a work computer, 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.<sup>45</sup> 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).<sup>46</sup> 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.

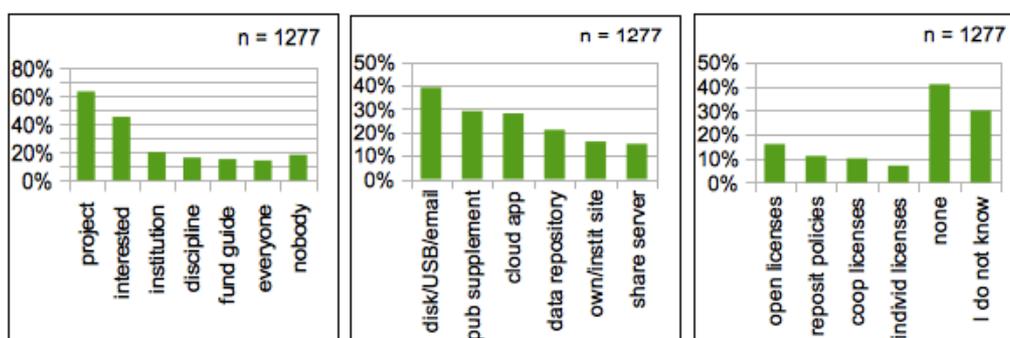
The typical way for researchers to grant access is via physical disks/USB/email, as supplementary material with publications, and via cloud applications. Data repositories, remote servers/share drives, and/or personal/institutional websites are also used to some extent. Early-career researchers use data 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.<sup>47</sup>

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.<sup>48</sup> 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

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

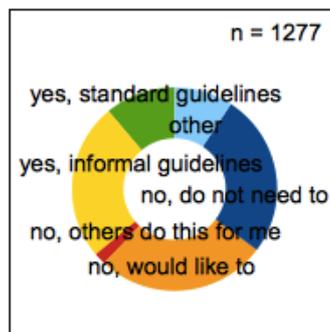
<sup>47</sup> <https://tla.mpi.nl/>

<sup>48</sup> <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.<sup>49</sup> 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.<sup>50</sup>

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.

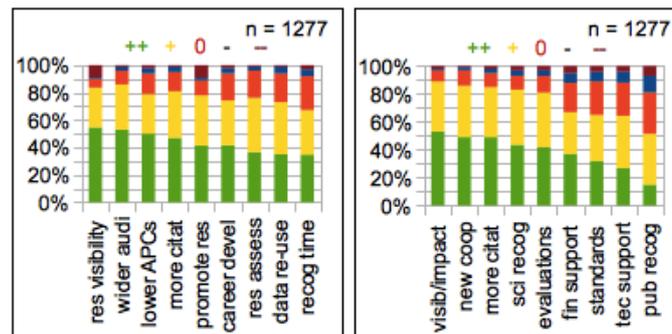
*Good Practice on Rewarding Open Data:* The Open Science Framework (OSF) is an open source service from the Centre for Open Science which encourages journals to reward researchers with badges in publications for sharing data and (preregistered) methodology.<sup>51</sup>

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<sup>52</sup> and the Working Group on Incentives & Rewards under Open Science<sup>53</sup>.

### 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).<sup>54</sup> 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<sup>55</sup> 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.<sup>56</sup>

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.

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

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

<sup>54</sup> [https://ec.europa.eu/research/era/pdf/era\\_progress\\_report2016/era\\_progress\\_report\\_2016\\_technical\\_report.pdf](https://ec.europa.eu/research/era/pdf/era_progress_report2016/era_progress_report_2016_technical_report.pdf)

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

<sup>56</sup> [www.consilium.europa.eu/en/meetings/compet/2016/11/st14926\\_en16\\_pdf/](http://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,<sup>57</sup> 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<sup>58</sup> project provides a description of the qualifications, skills, competences and training required for data professionals as in Figure 3.1.<sup>59</sup>

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).<sup>60</sup>

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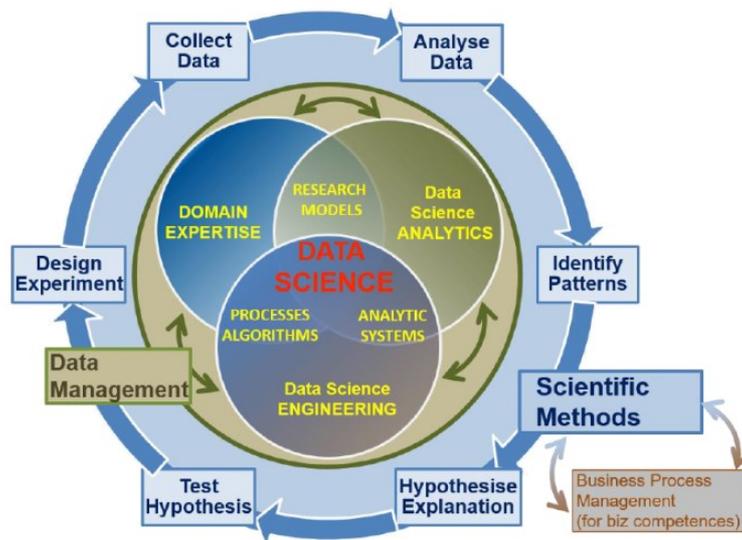
<sup>57</sup> <http://ec.europa.eu/research/openscience/index.cfm?pg=home&section=monitor>

<sup>58</sup> <http://edison-project.eu/>

<sup>59</sup> 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](http://edison-project.eu/sites/edison-project.eu/files/filefield_paths/edison_cf-ds-draft-cc-v07_0.pdf).

<sup>60</sup> <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<sup>61</sup> 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 Societize,<sup>62</sup> and finally the capacity to

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

<sup>62</sup> <http://www.societize.eu/?q=eu/content/societize-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,<sup>63</sup> 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<sup>64</sup> 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<sup>65</sup> and international organisations (e.g. COAR,<sup>66</sup> Knowledge Exchange,<sup>67</sup> IFLA,<sup>68</sup> and SPARC Europe,<sup>69</sup> see Figure 3.2).

Of the eighteen stakeholders who provide workshops, OpenAIRE, JISC, SURF, IFLA, Right to Research Coalition<sup>70</sup> 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.<sup>71</sup> COAR and OASPA<sup>72</sup> 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

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<sup>63</sup> [http://ec.europa.eu/research/researchersnight/index\\_en.htm](http://ec.europa.eu/research/researchersnight/index_en.htm)

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

<sup>65</sup> <https://www.jisc.ac.uk/>

<sup>66</sup> <https://www.coar-repositories.org/>

<sup>67</sup> <http://www.knowledge-exchange.info/>

<sup>68</sup> <https://www.ifla.org/>

<sup>69</sup> Mapping Open Science & Open Scholarship in Europe, December 2016, SPARC Europe.

<http://sparceurope.org/wpcontent/uploads/2017/01/SPARCEuropeMappingOpenScienceinEurope.pdf>

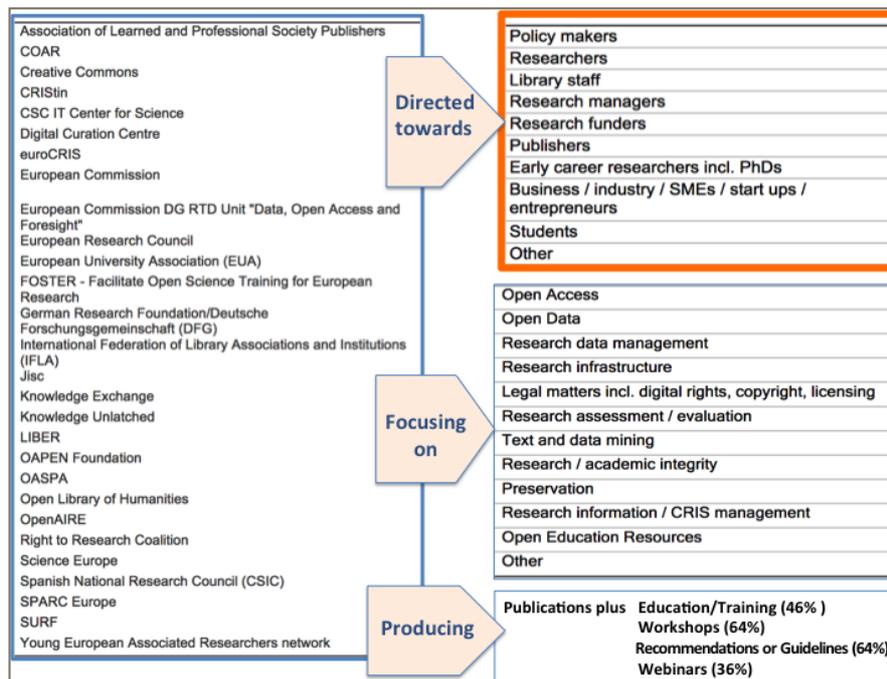
<sup>70</sup> <http://www.righttoresearch.org/>

<sup>71</sup> <https://www.alpsp.org/>

<sup>72</sup> <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.<sup>73</sup>

**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.<sup>74</sup> 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)<sup>75</sup> contention that 'the only thing that really works is deposit mandates', is supported by several international author surveys conducted by Alma Swan<sup>76</sup>, across all disciplines,

<sup>73</sup> For all information on the New Modernisation Agenda, please consult [https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-1062784\\_en](https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-1062784_en).

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

<sup>75</sup> 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.

## 4.2. The European Skills, Qualifications and Competencies Landscape<sup>77</sup>

**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
<p>Research competencies:</p> <p>Grant application writing skills;</p> <p>Research management &amp; leadership;</p> <p>Knowledge of research methodologies &amp; technologies;</p> <p>Research ethics &amp; integrity.</p> <p>Communication skills:</p> <p>Communication &amp; presentation skills, written &amp; oral;</p> <p>Communication &amp; dialogue with nontechnical audiences, public engagement;</p> <p>Teaching skills;</p> <p>Use of science in policymaking.</p>	<p>Digital competencies:</p> <p>Confident and critical usage of information and communications technology for work, leisure and communication.</p> <p>Learning to learn:</p> <p>Ability to effectively manage one’s own learning, either individually or in groups.</p> <p>Social and civic competencies:</p> <p>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.</p>	<p>Intellectual freedom;</p> <p>Adherence to recognised ethical practices;</p> <p>Professional responsibility;</p> <p>Professional attitude;</p> <p>Contractual and legal obligations;</p> <p>Accountability;</p> <p>Good practice in research (e.g. reliable backing up of data);</p> <p>Dissemination and exploitation of results is promoted;</p> <p>Public engagement is promoted;</p> <p>Researchers should take advantage of available supervision in a structured way;</p> <p>Senior researchers have a responsibility to manage and nurture younger researchers well;</p> <p>Continual professional development is promoted</p>	<p>Recognition of researchers as professionals on a career path (from postgraduate level upwards);</p> <p>Research environment should be stimulating and safe;</p> <p>Career development should be promoted;</p> <p>Access to research training and continuous development;</p> <p>Intellectual property rights should be protected;</p> <p>Co-authorship should be viewed positively;</p> <p>Evaluation/appraisal systems should be provided</p>

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).

## 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<sup>78</sup> document and

<sup>77</sup> See also [https://ec.europa.eu/ploteus/search/site?f\[0\]=im\\_field\\_entity\\_type%3A97](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-efq>.

associated EuroPass<sup>79</sup> 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;<sup>80</sup> 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.<sup>81</sup>

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.<sup>82</sup>

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.<sup>83</sup> 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).<sup>84</sup>

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

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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.

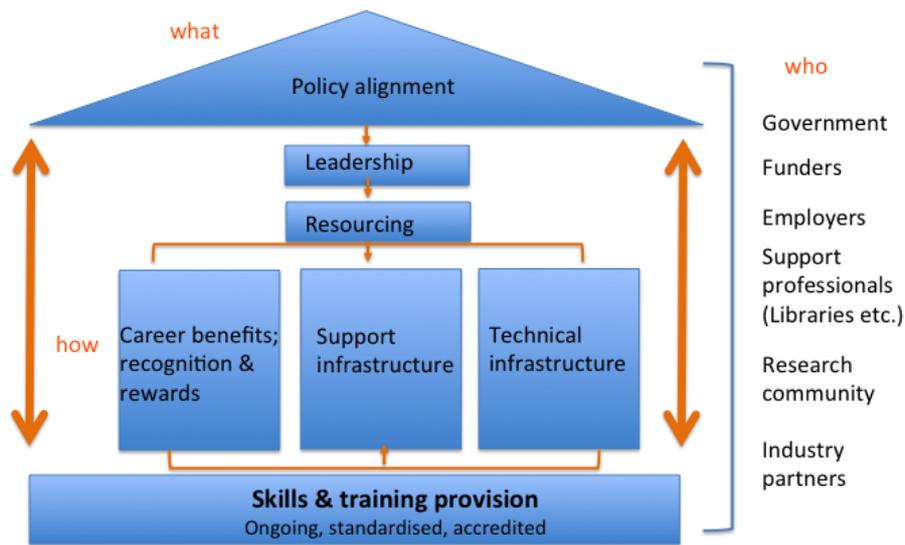
82 [http://www3.weforum.org/docs/WEF\\_EGW\\_Whitepaper.pdf](http://www3.weforum.org/docs/WEF_EGW_Whitepaper.pdf)

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](https://ec.europa.eu/research/openscience/pdf/realising_the_european_open_science_cloud_2016.pdf)

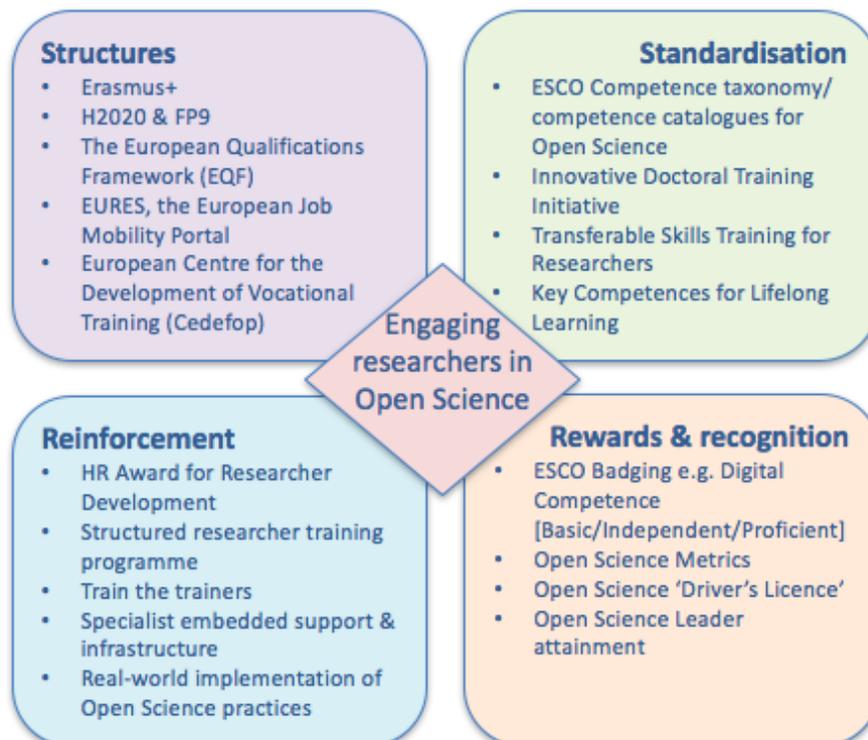
systems and incentives and backed by all entities involved in European research at every level. Figure 4.3 is a representation of that structure and the recommendations offered in this report are made with this structure in mind.

**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<sup>85</sup>**

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)<sup>86</sup>**

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.<sup>87</sup> 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.

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<sup>85</sup> [http://ec.europa.eu/research/era/era\\_communication\\_en.htm](http://ec.europa.eu/research/era/era_communication_en.htm)

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

<sup>87</sup> [http://www.eua.be/eua/jsp/en/upload/Salzburg\\_Report\\_final.1129817011146.pdf](http://www.eua.be/eua/jsp/en/upload/Salzburg_Report_final.1129817011146.pdf)

The recommendations have since been revisited (2010)<sup>88</sup> and expanded upon (2016)<sup>89</sup> 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:

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88 [http://www.eua.be/Libraries/publications-homepage-list/Salzburg\\_II\\_Recommendations.pdf](http://www.eua.be/Libraries/publications-homepage-list/Salzburg_II_Recommendations.pdf)

89 [http://www.eua-cde.org/downloads/2016\\_Taking%20Salzburg%20Forward.pdf](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.<sup>90</sup>
- 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 types of Open Science skills are required at different career stages. In addition, the broader public

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<sup>90</sup> Addressed by both the Open Science WG on Incentives & Rewards and the Open Science WG on Alternate Metrics.

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 organisations 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-Skłodowska 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

**European Commission (2017)** EuroPass Guidelines:

<http://europass.cedefop.europa.eu/documents/curriculum-vitae/templates-instructions>

**European Commission (2017)** 'Future Skills processor' - Competence profiles for the media sector based on ESCO [webpage] 23-01-2017

<https://ec.europa.eu/esco/portal/news/2f975ecc-3d63-42db-9e2c-2e0fabdd65e2>

**ESCO (2017)** European Skills, Competences, Qualifications and Occupations [website]

<https://ec.europa.eu/esco/portal/home>

**FOSTER (2017)** The next phase of FOSTER: what you can get out of it,

<https://www.fosteropenscience.eu/content/next-phase-foster-%E2%80%93-what-can-you-get-out-it-0>

**LERU (2017)**. LEARN toolkit of best practice in research data management, <http://learn-rdm.eu/en/research-data-management-toolkit-now-available/>

**Wilsdon et al. (2017)** Next-generation metrics: Responsible metrics and evaluation for open science Report of the European Commission Expert Group on Altmetrics, Brussels, European Commission, March 2017.

<https://ec.europa.eu/research/openscience/pdf/report.pdf#view=fit&pagemode=none>

**Bratislava Declaration of Young Researchers (2016)**

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

**Davidson, J. (2016)** Fostering open science practice through recognising and rewarding research data management and curation skills. In: Bisto, C. and Raju, R. (eds.) *LIS Education and Research*

*in a Dynamic Information Landscape: Proceedings of the Library and Information Studies Centre 75 Years Commemorative Conference.* University of Cape Town Libraries: Cape Town, pp. 63-75. ISBN 9780799225266 (doi:[10.15641/0-7992-2526-6](https://doi.org/10.15641/0-7992-2526-6)). <http://eprints.gla.ac.uk/116867/>

**Demchenko et al. (2016)** 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](http://edison-project.eu/sites/edison-project.eu/files/filefield_paths/edison_cf-ds-draft-cc-v07_0.pdf)

**European Commission (2016)** A New Skills Agenda for Europe: working together to strengthen human capital, employability and competitiveness {SWD(2016) 195 final}, June 2016, <http://ec.europa.eu/social/main.jsp?catId=1223>

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

**Vuorikari et al. (2016)** DigComp 2.0: The Digital Competence Framework for Citizens. Update Phase 1: the Conceptual Reference Model.

**Riina Vuorikari, Yves Punie, Stephanie Carretero Gomez, Godelieve Van Den Brande, European Union,** <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/digcomp-20-digital-competence-framework-citizens-update-phase-1-conceptual-reference-model>

**Hubbard, B. (2015)** Getting the rights right - or, When policies collide!, UKSG Webinar, 19 May 2015. Available: <http://www.uksg.org/webinars/oapolicies>. (05 August 2015).

**Knoth & Pontika (2015)** 'FOSTER Open Science Taxonomy', by Petr Knoth and Nancy Pontika, Version 3 02.09.2015,  
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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.

*Studies and reports*

