

Spanish academic libraries' perceptions of Open Science. Drivers and barriers, level of knowledge and training

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This paper reports on the perceptions of Spanish academic libraries regarding Open Science (OS). OS is irrupting into academia and academic librarians need to support researchers. On the other side, researchers need to be ready to change their scientific behaviour in relation to publications and research data. We conducted a focus group with 8 academic librarians. We also sent a survey to ($N = 67$) academic libraries, obtaining a response rate of 71.6%. In the survey, we asked for drivers and constraints for OS services as well as for any training taking place. Our results show that facilitators are the system relationships ($SD = 4.74$) and internal promotion of systems relationships ($SD = 4.54$). In relation to the level of knowledge of OS, both researchers ($SD = 3.27$) and librarians have a high level in terms of the OA area ($SD = 4.15$) but little development of the rest of the components of OS. On the other hand, in relation to training librarians, results indicated that OA ($SD = 4.79$), Open Data ($SD = 4.79$) and new evaluation models ($SD = 4.79$) should be part of the training for researchers. The results of the focus group reinforce some of the indicators mentioned. We conclude that academic libraries may train researchers in OS through the acquisition of new skills and trainers-training and with the strategic support of the university. We argue that academic incentives and a change in research accreditation are also needed to shift researchers' perceptions in relation to OS.

Keywords: Open-Science, librarians, mixed-methods, Information Science, academic libraries

1. Introduction

This paper presents the results of the perceptions of Open Science of academic libraries in Spain. The study is part of a research project in relation to Open Science (OS) in Spain in which various stakeholders (editors, researchers and academic libraries) express their perceptions of the uses and practices of OS (González-Teruel et al., 2022; Melero et al., 2022). According to Abadal (2021), OS is an umbrella under which some pieces need to be connected to remove barriers at any stage of the research process. These pieces vary depending on the perspective embraced.

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As such, according to FOSTER Plus project,¹ open access (OA) to publications, open research data, open-source software, open collaboration, open peer review (OPR), open notebooks, open educational resources (OER), open monographs, citizen science and research crowdfunding fall into the category of Open Science. The European Commission (2019), in turn, established that OS is underpinned by eight pillars: FAIR Data, Research Integrity, Next Generation Metrics, Future of Scholarly Communication, Citizen Science, Education and Skills, Rewards and Initiatives and the European Open Science Cloud (EOSC).

Vicente-Saez and Martínez-Fuentes (2018) performed a systematic literature review in search of a definition of OS, concluding that it is “a transparent and accessible knowledge that is shared and developed through collaborative networks”. The principle and applications of OS emerged in response to the concerns of replicability, transparency and reproducibility, the result being better science (Norris & O'Connor, 2019; Pontika et al., 2015). OS also emerges as a response to transformative technological change and web connectivity (Abadal, 2021; Bahlai et al., 2018; Bartling & Friesike, 2014).

Academic libraries support researchers in their research cycle. In the first phase, libraries sensitized researchers to open access and to promoting and managing the services that make it possible to report and deposit publications. The extension of the movement to the entire scientific process has led libraries to diversify their support, and it is then that they have an opportunity to become key partners in their institutions in relation to providing other OS services. Some such services might include, for instance, training staff in research data management, developing policies for the institutional repository or propagating OS (Ogungbeni et al., 2018; Boté-Vericad & Healy, 2022).

Although literature on libraries and OA and the changing roles of libraries with respect to OS have been identified, evidence and global studies on Open Science from the perspective of libraries are still limited. Hence, there is a need to know more about perceived OS knowledge and training among academic libraries, as well as to identify facilitating and blocking factors for OS posed by university libraries.

On the other hand, while the reviewed literature shows that several studies have been conducted worldwide, there is a gap at a local level, as in the case of Spain. As the LIBER Roadmap states, libraries also need to advocate locally for Open Science (Ayrís et al., 2018a). In this way, obtaining evidence in the Spanish context will help to extend the impact of the work of libraries at a global level. This, together with the changing movement surrounding Open Science that has taken place in Spain in recent years, has motivated researchers to delve into the topic of OS and libraries.

In this paper, we pose the following research questions:

RQ1: Which are the perceptions of academic libraries in relation to the drivers and barriers of Open Science?

¹<https://www.fosteropenscience.eu/content/what-open-science-introduction>.

RQ2: Which are the perceptions of academic libraries in relation to the level of knowledge about Open Science (of researchers and of themselves as library staff)?

RQ3: Which Open Science training is provided at their institutions?

This paper first presents a literature review, and second, the methodology. Thirdly, it presents the results of the questionnaire and focus group and their relation to the pertinent questions. Finally, it discusses the results and conclusions drawn from the research questions.

2. Literature review

2.1. Open Science concepts

Open Science is the practice of science in such a way that others can collaborate and contribute and in which research data, lab notes and other research processes are freely available, under terms that allow for the reuse, redistribution and reproduction of the information. It is based on the principles of inclusion, fairness, equity, and sharing, and seeks to change the culture of academic practice, which can often be hierarchical and conservative (Bezjak et al., 2018). Open Science encompasses unhindered access to scientific articles, data from public research – including open access publishing – open data sharing, open evaluation and rigorous peer review (Mendez & Lawrence, 2020).

There are various recommendations (UNESCO, 2021; OECD, 2021; Bartling & Friesike, 2014) regarding Open Science, and many definitions have emerged from scientific literature. Abadal (2021) and Méndez (2021) pointed out that OS is a radical transformation in how scientific research is conducted. Its benefits include transparency, reproducibility and a better social impact on research. Collaboration and dissemination of research results are essential elements of OS. According to Méndez (2021), OS is “academic research that is collaborative, transparent, and reproducible, the results of which are publicly available”. In a bibliographical review, Abadal and Anglada (2020) showed the evolution of the concept of OS, arguing that the concept of OS has neither universal acceptance nor a unique definition (Ogungbeni et al., 2018).

2.2. The role of academic libraries in providing services for Open Science

Academic libraries play an important role in academic institutions with regards to OS because of their connections to researchers and their long-standing tradition in advocating for OA. In the first phase, libraries sensitized researchers to open access and to promoting and managing the services that make it possible to report and deposit publications. The extension of the movement to the entire scientific process has led libraries to diversify their support and it is then that they have an opportunity to be

key partners in their institutions in relation to providing other OS services. Although there is no clear definition of the role of libraries within the whole panorama, and not all of them have the resources to do as much as they might like with OS, libraries can take a range of steps in the right direction (Ayrís et al., 2018a; EOSC, 2021).

Some of these steps compiled in the literature address topics such as OA policies, OA publications and repositories (Anglada & Abadal, 2018; Swiatek, 2019), Open Data and research data management (Cox et al., 2017; Ashley et al., 2018), data curation and stewardship (Bishop et al., 2021; Engelhardt et al., 2022) and training of researchers (Boté-Vericad & Healy, 2022) and librarians (Santos-Hermosa & Atenas, 2022).

The research community has recognized the role of libraries in OA (LERU, 2018; Giustini, 2021; Sultan, 2021) since OA to publications has often been led institutionally by university libraries. Beyond this, there is a great conceptual framework of studies highlighting the challenging issues and emerging roles of libraries in terms of OS (Ogunbeni et al., 2018; Revez, 2018; Tzanova, 2020; Redkina, 2022). For instance, in one qualitative review, Ogunbeni et al. (2018) found that challenges for academic libraries in relation to OS include data anonymization, data citation, and protocols for assessing data quality. In this study, authors concluded that libraries should focus on data repositories to encourage researchers to embrace OS. Ayrís (2017) proposed different actions the European Commission could take in relation to Open Science, as well as agreements on interventions on policy actions, such as fostering open science or developing research infrastructures.

In relation to research data management, FAIR principles emerge inspired by OS (Mons et al., 2017) and academic libraries offer guidance to researchers on how research data must accomplish these principles (Wilkinson et al., 2016; Swiatek, 2018). However, in some situations, research data cannot fall under the FAIR principles and must be preserved for ethical or contracting reasons (Carballo-García & Boté-Vericad, 2022; Boté & Termens, 2019). In a systematic review in relation to research data management in academic libraries, Boté-Vericad and Healy (2022) found that training was a common point in relation to research data management. Training may involve academic librarians acquiring new skills such as data sharing, data reuse, data management planning and practical tools.

In the United States, Yu (2017) analysed the research data service strategies (RDS) in literature and used the results of two surveys by the Association of Research Libraries (ARL) and the Association of College and Research Libraries (ACRL) and the research data service website of 73 libraries which participated in the surveys in 2009 and 2013 respectively. She found that libraries covered the life cycle of RDS in relation to the services offered. These services were: a) any research data management services, b) data management planning, c) metadata consultation and tools, d) data archiving by the library, e) providing an institutional repository, and f) data sharing and access. She concluded that while they explored academic libraries in the United States and took advantage of the OA to advice researchers, it proved challenging to have trained staff and funding.

Other analysis of activities that libraries are developing around OS include a report carried out by the France Ministry of Education (Carole et al., 2021) and an international OCL study (van der Werf, 2020). The results show certain convergences of activities between French and foreign libraries, such as supplying an institutional archive, promotion of open content, assistance to researchers and the sharing of activity devoted to research data management. On the other hand, the OCLC report highlighted some initiatives less present in the actions of libraries, such as publishing, digitization and bibliometrics or participation in evaluation. In this sense, another of the emerging domains in which academic libraries are getting involved, more recently, is that of Open Educational Resources (Santos-Hermosa, 2019; Santos-Hermosa et al., 2020; Santos-Hermosa; Proudman & Corti, 2021).

Finally, and under the belief that libraries are capable of providing leadership to the global movement of Open Science (Ayrís & Ignat, 2018), there are also interesting contributions from professional library associations, such as the material produced by the League of European Research Universities (LERU) and the Association of European Research Libraries (LIBER). These have created roadmaps with recommendations, action proposals and complementary tools (such as checklists) to help libraries prepare for Open Science (Ayrís et al., 2018a; Ayrís et al., 2018b).

2.3. Librarians' perceptions of Open Science

The attitudes and perceptions of librarians regarding Open Science are not a topic that has brought together as many studies as in the previous case on the role of libraries or even the perceptions of researchers, which have been more widely studied (Rath & Wang, 2017; Nicholas et al., 2017; Tenopir et al., 2020).

Despite this gap in literature, there are a few studies into the subject scattered around the world. For instance, in Pakistan, Sultan and Rafiq (2021) studied libraries' awareness and perceptions of OA, and Asiq and Warraich (2022) focused on their perceptions of the role of data librarianship. These authors performed a questionnaire, obtaining ($N = 132$) responses from librarians and finding that while developing new services – such as data management – would generate a better image of libraries, the major challenges were missing data policies and limited training opportunities for data librarianship roles.

In Zimbabwe, scholars' attitudes towards and perceptions of institutional repositories were studied by Masona Tapfuma and Geraldine Hoskins (2019). In a collaborative project between the University of Sheffield and higher education institutions in Rwanda, Cox and Abbott (2021) explored librarians' perceptions of open scholarship. Three senior librarians and four experts with profound knowledge of the country participated in a workshop week in Sheffield. Their results showed that, in Rwanda, researchers are under pressure to secure external funding and publish internationally, since funding is scarce. They also found that universities do not prioritize research and that technological infrastructure is less available than in the northern hemisphere. The lack of funds and the failure of open access policies undermine the librarian's role, and librarians' perceptions align with the country's deficit.

3. Methodology

Our methodology consisted of two parts. First, we performed a focus group with a purposive sample of 8 research librarians from 8 different universities. The goal of this focus group was to find patterns among participants in relation to how OS was carried out in their institutions. We performed the focus group in May 2021 – because of COVID-19 it was conducted online. The focus group was audio recorded and had a total length of 1 hour and 30 minutes. Audio recording was manually transcribed verbatim. These were then analysed by the two authors of the paper using inductive analysis (Mayring, 2010). To validate the code reliability, both researchers codified a sample individually and an intercoder reliability test was performed using Krippendorff's Alpha methodology (Krippendorff, 2004). The focus group transcription had 9,500 words. Each author reviewed and coded a piece of 1,000 words. On applying the test, results were $\alpha = 0.820$, indicating a high degree of consistency between both researchers.

We analysed the corpus using Atlas.TI software v.21.0. We clustered our findings into three main themes based on our research questions, which are also expected in the Mayring approach (Braun & Clarke, 2006; Boté-Vericad, 2022):

- 1) barriers and drivers of OS;
- 2) level of knowledge in OS (amongst researchers and librarians); and
- 3) training carried out by institutions.

There were a total of 7 main codes and 39 subcodes (see Table 1).

Second, we addressed a questionnaire to academic libraries from the Red de Bibliotecas Universitarias Españolas (REBIUN): the academic library network of higher education institutions in Spain. More specifically, we sought libraries offering support services to researchers and with a research repository ($N = 67$). The online survey, sent in May 2020, was aimed at Library Research Support units, specifically to library staff responsible for OA repositories or OS services. A descriptive and statistical analysis of the responses was conducted using SPSS v27 and Microsoft Excel Office 365. We obtained a sample of ($N = 48$) answers, which corresponds to 71.6% of the total population.

The survey comprised 13 questions, each with a specific list of response options. The full survey instrument is available (Santos-Hermosa & Boté-Vericad, 2023)*, divided into two main sections: one dedicated to OS (Q1–Q4 concerned barriers to and facilitators of OS and perceptions about researchers' and librarians' knowledge of OS) and another focused on Training (Q5–Q13 concerned content, strategies, formats, providers, etc.).

Depending on the questions, answers could be single, multiple or 5-point LIKERT Scales (e.g., from “strongly disagree” to “strongly agree”) which were translated into a numerical scale from 1 to 5 for quantitative analysis and statistical processing. 2 people experts in quantitative analysis reviewed the survey.

For the quantitative analysis of the Likert-scale questions, the mean and standard

Table 1
Coding scheme used in qualitative analysis (focus group)

Codes	Subcodes
100_OS_Implementation	101_OC_facilitators
	102_OS_Barriers
200_OS_Implementation_Factors	203_Funding
	204_Time
	205_Recognition
	207_Influence of the environment
	208_Age
	209_Support staff
	210_Incentives
	211_Metrics
	212_Need
	213_Inequality
	214_Lack of understanding
	215_Delegated_diposit
	216_Assesment_system
	217_OA_Requirement
	218_Attitude
	219_Awareness
300_Training_Actions	301_Type_of_Training
	302_Content_Training
	303_Modality_Training
	304_Strategy_Training
	305_Assessment_Training
	306_Problems_Training
	307_Units_Training
	308_Target_Training
400_OS_Knowledge's_LibrariansPerception	401_OS_Knowledge's_Librarians_about_themselves
	402_OSc_Knowledge_Librarians_about_researchers
500_OCs_Definition	501_Lack of specification
	502_Alignment between teams
	503_Good practices
600_Elements_OCs	601_Open_Access
	602_Open_Data
	603_Open_Publications
	604_Open_Review
	605_Open_Educational_Resources
	606_CitizenScience
700_Institution	701_Institutional_policy
	702_Institutional_involvement
800_Other	

deviation was calculated for all sections. In a Likert questionnaire, one person who strongly agrees with a question and one person who strongly disagrees with it can be numerically compensated by assigning numerical values to their responses. For example, on a 5-point Likert scale, the numerical values could be 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, and 5 for strongly agree. If one person strongly agrees with a question and another strongly disagrees, their scores will cancel each other out when averaged with the scores of other respondents. This

Table 2
General description of data by sections

	Mean	Std. deviation	N
Barriers	3.6765	0.57424	48
Drivers	4.3709	0.56357	47
Researchers' perception	2.6236	0.60279	48
Librarians' perception	3.2792	0.91208	48
Training	3.2813	0.66057	48
Content	4.6181	0.42382	48

ensures that the overall score for the group accurately reflects the distribution of opinions, and that no one individual's response unduly influences the results. At the end of each section of the survey, a box was provided for free text comments, which were also taken into account in the qualitative analysis and discussion of the results.

Finally, we conducted a correlation analysis, but the correlations were not strong. Some of the results include the following: Perception of Librarians versus Training had a correlation coefficient of 0.656, Researchers' Perception versus Librarian Perception had a coefficient of 0.469, Factors versus Barriers had a coefficient of 0.417, Researchers' Perception versus Training had a coefficient of 0.349, and Contents versus Perception of Librarians had a coefficient of 0.337.

4. Results

Of the total number of topics surveyed (Table 2), the highest number of responses related to training and facilitators of OS, with a higher mean and slow standard deviation.

Below, the results are presented in more detail and are broken down into topics.

4.1. Barriers that hinder the Open Science model in research

The results (Table 3, Q1) show that the main barrier to OS is the assessment system, followed by a lack of drive. Behind this lies the misalignment of units within the institution; lack of training and lack of awareness also seem to be significant. On the other hand, and according to the answers obtained, age would be the lowest barrier, so this aspect together with a lack of time might be less critical. It is worth highlighting the high participation level of the respondents ($N > 45$) in most of the answer options; there are even three answers that were selected by all the respondents ($N = 48$). This suggests that opinions among librarians converge considerably in terms of all the barriers presented. However, it is also observed that, in the case of deficiencies in infrastructure and other three barriers (lack of integration, resources and communication), there was a dispersion of data greater than 1, which may indicate that the respondents have a subjective view of this theme. For instance, some libraries may provide good infrastructures or have enough resources and may therefore not consider them high-priority barriers. Other libraries may have the opposite situation and therefore consider that they are significant barriers.

Table 3
Barriers that hinder Open Science

	<i>N</i>	Mean	Median	Std. deviation
Research assessment system	47	4.55	5	0.880
Institutional lack of drive or policy	48	4.21	4	0.922
Misalignment of support teams, research teams and management	45	3.91	4	0.874
Lack of training	47	3.83	4	0.940
Lack of awareness	47	3.72	4	0.926
Management difficulties	47	3.23	3	0.937
Lack of time	48	3.17	3	0.996
The age or consolidation of the research staff	45	3.11	3	0.745
Deficient technological infrastructure	48	3.48	3	1.052
Lack of integration of CRIS and repositories	47	3.57	3	1.078
Lack of Communication between librarian and IP	47	3.68	4	1.086
Lack of resources	47	3.62	4	1.095
Valid N (listwise)	41			

Therefore, the data show that the barriers to OS are a combination of different reasons, with a strong coincidence in the accreditation system and the lack of drive, but also the dispersion of opinion based on the deficiencies of each institution. The focus group results reinforce this pattern with coincidence amongst the respondents, who consider that “the evaluation model focused on the impact factor is an important barrier” and that “open science is an opportunity, but if the logic of funding, evaluation and measurement of research goes the other way, then traditional science will continue to be promoted and preferred”. In the same vein, they also noted the cost of publication in OA (pay-per-publish model, as it was referred to by one respondent) and lack of incentives. There were also concerns about the lack of alignment of institutional units, “both the government teams and the research support units [...]; not just libraries, but also the entire research area or project managers, should be all aligned”.

Another barrier detected is the contradictory attitude of researchers, in the sense that “they want to use open access so that the resources they need are available, but putting their own resources in open access generates rejection and causes doubts”. Finally, in terms of the lower incidence of age relative to barriers, the focus group of librarians reports that it is more difficult to involve researchers of a certain age in OS topics and that the most motivated group consists of young people.

4.2. Facilitators of Open Science

According to the responses (Table 4, Q2), the main facilitator for OS is its relation to accreditation systems. This is followed by providing academic and economic incentives and by relationship to internal promotion, institutional policies, and support staff. The rest of the facilitators mentioned seem to constitute a very balanced response. Incentives and policies have a slightly higher deviation, so they are seen as lesser facilitators by a small group of libraries.

Table 4
Facilitators of Open Science

	<i>N</i>	Mean	Median	Std. deviation
Academic incentives	46	4.46	5	0.887
Financial support	46	4.35	5	0.795
Relationship to accreditation systems	46	4.74	5	0.612
Relationship to internal promotion systems	46	4.54	5	0.751
Institutional policies	47	4.32	5	0.862
Support staff	47	4.32	4	0.629
Coordination of areas	45	4.27	4	0.688
Training	47	4.26	4	0.736
Other	46	3.45	3	0.795
Valid N (listwise)	45			

The focus group results contribute some possible explanations and examples for this situation. Some OS facilitators pertain to their own researchers' context and concept of need in relation to the accreditation systems and requirements of funders. Three librarians reported that "there is a sensation of need, of demand, or obligation" and that "those [researchers] who are working on European projects or with grants calls that require open access" are more convinced. Another adds that the most highly motivated researchers are those "who feel obliged because they are in an environment or discipline in which it is required".

In addition, the focus group commented on a relationship between incentives and support staff, since "the incentives would be more support staff for all these library tasks or research managers or support staff within the projects". They also highlighted that "the support of the library is a facilitating condition" and that, in some institutions, "a support librarian is already assigned to each European project, who advises on open access and research data".

Beyond the motivations of researchers and support staff, respondents also consider that institutions play an important role and that they should be more committed and lead the OS ecosystem, not only through policies but also in terms of aligning the different teams. Some quotations clearly demonstrate this: "For this to be a success at the university, I believe that both the directors of research centres, as well as the researchers and other agents involved, have to agree. We all have to be aligned" or "coordination between the different agents makes work much easier. Coordination with the Research Office, with the Vice President for Research or with the departments helps to move towards open science". Finally, librarians indicated that publicizing good practice among researchers would also be a facilitator, in the sense of "looking for a researcher from each area, who does good practices and who is a bit like the reference model for others".

4.3. *Perceptions of knowledge of Open Science amongst researchers and librarians*

4.3.1. *Researchers' knowledge*

The Openness area in which librarians perceive researchers to be most knowledgeable (Table 5, Q3) is OA, followed by research integrity. On the contrary, the

Table 5
Researchers' knowledge of Open Science

	<i>N</i>	Mean	Median	Std. deviation
Open access	48	3.27	3	0.893
Open data	47	2.28	2	0.826
Open peer review	48	2.35	2	1.021
New models of evaluation	46	2.22	2	0.892
Integrity/Ethics of the research_	44	3.14	3	0.955
Open educational resources (OER)_	47	2.49	3	0.975
Valid N (listwise)	43			

topics perceived to be less well known relate to new models of assessment² and OPR. Regarding this latter topic, a very low average is observed, which may indicate a perception of little knowledge about OPR. In the middle of the topics of greater and lesser knowledge for researchers (Table 5, Q3) is that of Open Educational Resources (OER), the position of which could relate to the greater or lesser presence of teaching collections deposited in repositories.

The results of the focus group suggest that researchers linked to research projects that require OA have more knowledge of it. Some summarize this by saying "For research teaching staff without funding, the level is very low. However, for those with financing, it is between medium or medium-high" or that "knowledge is low unless you have found yourself in the position of having to participate in Open Science". According to librarians, awareness seems to be another important factor, since "Open Science researchers are only a small group that is very advanced and very aware of open science, but the rest do not follow". Librarians also concur that the level of knowledge is unequal, since researchers may know a lot about OA but not about the rest of the components, such as Open Data or OPR. However, this depends on the institution, so respondents refer to some cases in which researchers have an acceptable level of knowledge in those topics. For example, in the open review, respondents state that "unless you are a reviewer, the subject is far from you" or that "there is a lot of knowledge in case of those researchers who participate in peer review processes".

4.3.2. Librarians' knowledge

As for library staff's perception of themselves in relation to their level of knowledge of OS, statistical data (Table 6, Q4) show that the area in which they are most knowledgeable is OA. On the contrary, the topics perceived as less known are new models of assessment and OPR. This is the same pattern previously observed in researchers. On the other hand, the difference between researchers and librarians in terms OS knowledge seems to be in Open Data, which seems to be an area of greater knowledge for librarians.

²In terms to new and more qualitative assessment criteria, to reform the current system of evaluating research, in line with the San Francisco Declaration on Research Assessment (DORA) <https://sf.dora.org/>.

Table 6
Librarians' perceptions of Open Science

	<i>N</i>	Mean	Median	Std. deviation
Open access	48	4.15	5	1.052
Data	48	3.29	3	1.184
Open peer review	48	2.81	3	1.142
New models of evaluation	48	2.83	3	1.226
Open educational resources	48	3.31	3	1.055
Valid N (listwise)	48			

Table 7
Typologies of training performed

	<i>N</i>	Mean	Median	Std. deviation
General training	47	3.45	4	0.996
Open Science training	48	3.44	3	1.009
Open Data training	48	2.69	3	1.188
Wikipedia training	44	1.95	3	1.077
Repository training	48	3.75	4	1.101
Personalized training	46	3.41	4	1.087
Accreditation assessment training	47	4.11	4	0.914
Other training	44	3.66	4	0.888
Open training others	42	2.95	3	1.035
Valid N (listwise)	39			

It is worth noting that this question was answered by all the respondents ($N = 48$) and that in all responses there is a data dispersion greater than 1, which may indicate that the libraries have a subjective view of all the surveyed topics. This situation of dispersion and duality between institutions is also identified in the focus group. Some librarians point out that “knowledge about open data is exclusive to researchers with funded projects and librarians” and that “among librarians there is a medium-high level and, in some departments, even very high and very specialized”. Other librarians, on the other hand, acknowledge that “the level is unequal both among researchers and among librarians” and that “except for one or two fellow librarians who are being trained on the subject, there is still not a very general knowledge”.

4.4. Training performed in their institutions

Those surveyed stated that the training most commonly carried out in their institutions (Table 7, Q5) concerns advising on research accreditations. This follows training on the institutional repository and others based on a range of levels, areas and forms. OA content embedded in other training and general training is the next typology of training reported with a mean higher than 3. As such, this type of training was the most common in librarians' institutions.

Training on Wikipedia is less widely performed, as is specific capacity in data. In this example of data training, we can see the highest deviation (1.188), demonstrating the differing situations amongst libraries and suggesting that while some offer this

Table 8
Content which should be included in training

	<i>N</i>	Mean	Median	Std. deviation
Open access	48	4.79	5	0.651
Open data	48	4.79	5	0.544
Open peer review	48	4.48	5	0.684
Creative commons	46	4.17	4	0.739
New evaluation models	47	4.79	5	0.463
Open educational resources	47	4.64	5	0.529
Valid N (listwise)	46			

kind of training, others do not. Reasons for this vary; examples include a lack of resources or policies.

Respondents also provided answers regarding the content which should be included in training (Table 8, Q6). All of them ($N = 48$) agreed on three topics: OA, Open Data and new assessment models. There was also agreement, albeit to a lesser extent, regarding content concerning OER, OPR and Open citizenship. Statistical data show that all the means are higher than 4 (Likert scale) with a deviation lower than 1, meaning there was strong agreement among respondents.

When libraries were asked which training modality and models were most appropriate (Q7), synchronous modality was the most commonly selected option, with considerable parity between face-to-face ($N = 40$, 32.0%) and online ($N = 41$, 32.8%). Online courses such as MOOCs ($N = 23$, 18.4%) and self-training ($N = 21$, 16.8) obtained a weaker response, due to both the number of participants who selected these options and the frequency of responses (less than 50%). These results suggest that libraries prefer types of training in which learner(s) and instructor(s) are in the same place at the same time when learning takes place (synchronous learning), regardless of whether this is performed online or in person. This modality may be more convenient if there is a specific need for live discussion or interaction, or as a strategy for building community among learners. On the other hand, online courses and self-starting modalities involve more asynchronous learning in which instructors usually establish a learning path and students participate at their own pace. This might require more dedication of time and more difficulty in designing training. In addition, self-training materials tend to be more complicated and expensive, as with MOOCs (since this kind of platform requires investment and updating).

In terms of training strategies (Q8), there is a higher frequency (75%) amongst respondents who consider that organizing training within regulated undergraduate, postgraduate and doctoral courses is the most effective. The most concurrent strategies involve organizing training within research seminars or meetings ($N = 36$, 18.0%), training on demand for research staff or other interested groups ($N = 36$, 18.9%) and agreements with those responsible for research such as centre management, faculty or research group ($N = 34$, 17.9%). Surveyed individuals indicated that the least effective strategies include organizing training according to a pre-established catalogue and calendar (semestral/annual; $N = 21$, 11%) and monographic/specific

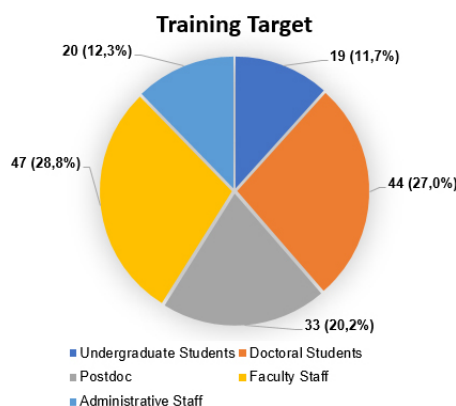


Fig. 1. Staff who received the training.

training according to topics of interest ($N = 25$, 13.2%). In terms of assessing the training carried out (Q9), participants indicated that the level of assessment was generally very high ($N = 9$, 18.0%) or high ($N = 20$, 40.0%).

Amongst the range of problems detected during training (Q10), differences in the degree of knowledge of the topics were the problem most selected by participants ($N = 32$, 34.0%). Next, the answers are more spread out, obtaining more frequent responses in differences of interest in the topic ($N = 15$, 16.0%), followed by low attendance and participation respectively ($N = 14$, 14.9%). According to a few respondents, the lack of academic recognition of training ($N = 12$, 12.80%) and lack of specialized information ($N = 7$, 7.40%) are the problems least present in training.

Libraries were asked about the institutional units promoting training in openness (Q11) and those which should carry them out (Q12). Most respondents considered that libraries ($N = 47$, 54.0%) are the units that most promote training within the institution. To a lesser extent, research Vice-rectorate units ($N = 20$, 23.0%) follow, along with Research support offices ($N = 14$, 16.1%). This suggests that those units might not be committed to OA training. Lastly, OA units or departments are the least targeted ($N = 6$, 6.9%). This result is probably due to the lack of this type of office in the institutions.

Similarly, respondents reported that library staff should carry out training ($N = 47$, 38.2). At the same time, faculty members ($N = 19$, 15.4%) and data managers ($N = 21$, 17.1%) were less commonly selected options, considering that those with data-intensive jobs could be possible candidates for training.

Finally, libraries were asked who was receiving the training (Fig. 1). Faculty members seemed to be the users who received the most training ($N = 47$, 28.80%), followed by PhD students ($N = 44$, 27.0%) and postdoc personnel ($N = 33$, 20.20%). Administration staff ($N = 20$, 12.30%) and students ($N = 19$, 11.70%) were the least trained, according to the respondents.

5. Limitations

The main limitation of this study is that the target population for the online survey was restricted to Spanish academic libraries. This population may condition the extrapolation of the results to other communities. Because of COVID-19 measures, the focus groups were limited to being conducted online. This issue could have resulted in losing part of the context of the focus group.

6. Discussion

6.1. OS drivers and barriers

Librarians' views on the drivers of and barriers to OS do not differ greatly from previous studies on the same topic (Cabello-Valdés et al., 2017; Ayris et al., 2018a; EOSC, 2021). However, since they are mostly based on the perceptions of researchers, the particularity of the librarians' view completes and provides nuances to the global overview.

Our results show that the research assessment system is considered a barrier and a driver at the same time. In this regard, Spanish academic libraries demonstrate a dichotomy and a lack of harmonization. As a barrier, this system conflicts with the values of OS, since traditional metrics do not encourage researchers to practise OS or to cultivate more open scholarly practices. As a facilitator, the regulatory framework and, more specifically, the requirement to deposit open publications and Open Data in calls for proposals for research funding is positively affecting OS. This latter point aligns with a study in which other librarians considered that complying with funders' mandates, such as EU OS Policy (Giustini et al., 2021), was one driver for OS.

In fact, rewards and evaluation are identified as key issues in the ability of universities to move to adopt OS practice (Ayris et al., 2018a). Researchers are embedded in incentive structures that reward other kinds of research behaviour separate from OS and more closely linked to the traditional process of knowledge creation and dissemination based on peer-reviewed publications in high-ranking journals (Gagliardi et al., 2015). EOSC (2021) has suggested adding a new criterion when evaluating researchers, such as an "EOSC support activities" certification that contributes to career advancement. LIBER (Ayris et al., 2018a) has also identified quantitative metrics as one of the strongest barriers to engagement in OS and it recommends the use of open scholarly metrics as a driver. Nevertheless, there are discussions on how open science/open scholarship metrics can function as "incentives" (Wouters et al., 2019). Other OS drivers identified by Spanish libraries include the relation with internal promotion and incentives. Echoes of similar results consider researchers' tenure and promotion (Nicholas et al., 2017) and the absence of incentives and rewards (EOSC, 2021) to be hurdles.

In this scenario, the adoption of a new assessment model becomes a major chal-

lenge. Some actions in this regard include calls made by researchers for a real change in accordance with the Declaration on Research Assessment (DORA) (Delgado-López-Cózar et al., 2021) and for a transition from a traditional evaluation model to another more in consonance with OS. For this, commitment from governments and evaluation agencies is needed at a macro level, and from institutions at a micro level. Some research funders, such as the Wellcome Trust, support this development (Ayrís, 2021) by requiring institutional alignment with DORA as a condition of funding. Some governmental networks, such as the Council for National Open Science Coordination (CoNOSC), are also taking action to reform research assessment systems in Europe.

However, this declaration of intent is not the only action that universities can carry out to push OS – they can also value and implement OSC as an institutional strategy. This was highlighted by librarians participating in this study, who considered that the lack of institutional drive and poor alignment between institutional units (researchers, research support departments and direction) are the second group of main obstacles to OS. The LERU roadmap that accompanies universities' efforts towards OS recommends establishing advocacy programmes and developing university leadership. According to Giustini et al. (2021), libraries can also collaborate and establish partnerships with various stakeholders to provide OS services and resources.

6.2. *Knowledge of OS*

The perceptions of academic libraries of their higher knowledge in OA and Open Data are supported by libraries' tradition in and advocacy of OA and by some evidence of current data management services offered by libraries. Since OS often starts with the OA to publications aspect, librarians have been leading this institutionally by raising awareness of open culture, dealing with publishing policies and copyright issues and managing digital repositories (OECD, 2015; Anglada & Abadal, 2018; Ayrís, 2021). As highlighted by Ayrís et al. (2018a), libraries have increased their commitment to improving OS governance and infrastructure since the EU and member states implemented Open Data policies in 2010. Lately libraries have also supported researchers and favoured OA by offering the transformative agreements and help in Open Data management plans (Anglada et al., 2020).

Scott et al. (2021) have identified a correlation between library contributions to OA repositories and librarians' attitudes towards OA. Some studies also confirm that, while academic libraries are fully aware of OA, they lack other OS-related topics (Sheikh, 2017; Ochoa-Gutiérrez & Uribe-Tirado, 2018; Sutan & Rafiq, 2021). As for Open Data knowledge, there are examples of services related to the promotion of OA (through repositories) and Open Data Research Management. A recent scoping review regarding the impact of library services on OS (Cox & Abbot, 2021) identified that the greatest number of studies were on OA, followed by some others on Open Data. However, there were few on Open Education or Open Citizenship.

Similarly, in terms of researchers' knowledge, results have also shown that, except for OA, there is little development of the different components of OS. Surveyed librarians perceived differing needs and varying knowledge depending on researchers, institutions and disciplines. For instance, although OPR is still at an early stage of development (Rath & Wang, 2017; González-Teruel et al., 2022), some institutions, such as the Spanish National Research Council (CSIC in Spanish), have been innovating in OPR services (Ayris et al., 2018a). There seems to be a discrepancy within the scientific community. While there is some progress towards OS, there is still a gap between researchers' positive attitudes towards OA and Open Data and the actual implementation of these into their practices (Heise & Pearce, 2020; Tenopir et al., 2020).

If we compare the vision of librarians with that of researchers, there is some connection regarding their perception of the facilitators of and barriers to open science (González-Teruel et al., 2022). At the level of institutional support and regulatory framework, both groups consider that OA promotion policies, incentives and the requirement or obligation of the research calls would be facilitators. On the other hand, in terms of the barriers, the perceptions of both groups coincide in the current evaluation system and the lack of incentives and support for publication.

In this sense, the results are directly related to current research activity being carried out in the institutions participating in the survey. As has been observed, the results depend on the OS elements being worked on, as well as the existing level of knowledge at each institution, thus reflecting the current institutional regulatory framework.

6.3. *Training*

Libraries are key partners in skills training for OS. The starting point used to be the institutional repository, OA policies and copyright services, but more recently, Open and FAIR data have also become a strong priority for libraries (Swiatek, 2019). Based on the European Commission's definition of OS Skills (O'Carroll et al., 2017), the research library community represented by LIBER (Ligue des Bibliothèques Européennes de Recherche – Association of European Research Libraries) went a step further and defined the skills needed for the effective use of OS. The result was the Digital Skills for Library Staff and Researchers Working Group and its OS Skills Visualization (McCaffrey et al., 2020).

In Spain, the General Assembly of Spanish Universities CRUE (2019), of which the REBIUN network is part, approved the document "Commitment of universities to Open Science", containing specific actions for the promotion of OS. One of them was to "Promote a cultural change in the agents of the R&D system through awareness and training in Open Science". As we have seen, the libraries surveyed have followed this CRUE commitment by offering training under a series of parameters: pre-eminence of content on OA and Open Data, with a preference for synchronous modality (with parity between face-to-face and online) and its integration into existing

regulated courses. Researchers and doctoral students are usually the main audience, and the library is simultaneously the institutional unit that most promotes and is most responsible for OS training.

In Europe, libraries are also often the main coordinators in charge of the OS training service, as shown in an OS training case study by Swiatek (2019). Some reference examples of data training in academic libraries include, for instance, the OS MOOC, created by Delft University of Technology; an OS Quest, by the university library of Luxembourg; an e-learning course on research data management, by Danish university libraries, or the development of OS skills programs by the EPFL Library in Switzerland. Most of these training programmes were created in collaboration with Centres or Departments of Technology (Norway), national frameworks for research data Management (Denmark) or the OpenAIRE's National Open Access Desks (NOADs) (Brinken & Swiatek, 2018; Swiatek, 2019).

As for strategies for reaching their audience, it has been identified that some European libraries are also integrating OS training programmes into their general institutional training plans and, where an OS strategy is in place, offering some career progression incentives and seeking OS “ambassadors” amongst senior researchers (Swiatek et al., 2020). One example of embedding OS elements into library courses is carried out by the University of Eastern Finland Library (UEF) (Saarti et al., 2020).

Although libraries play a fundamental role in training and raising awareness among researchers and academic communities and have been seen as the group most familiar with OS among various stakeholders (González-Teruel et al., 2022), they also need to reskill and be open to other OS components. There is some concern that LIS schools are neither preparing librarians for the future of Open Science and Scholarship nor equipping them with the research data and digital skills that future library users will expect of them (Rice, 2019; Santos-Hermosa & Atenas, 2022). According to results from the National Initiatives for Open Science in Europe (NI4OS) project (EOSC, 2021), libraries still need to improve awareness of the EOSC and develop more specific training in data support (Rice, 2019). It has been found that libraries experience low engagement in Citizen Science initiatives (Ayiris & Ignat, 2018); for this reason, the LIBER Citizen Science Working Group (2021) has recently launched a guide to Citizen Science skills for library staff. Another relevant field of action is that of Open Education (Puccinelli et al., 2020; Santos-Hermosa et al., 2021). In addition, bibliometrics and participation in the evaluation system are marginal in the immediate actions of libraries (van der Werf, 2020; Carole et al., 2021).

7. Conclusions

This paper has looked at drivers of and barriers to Open Science (RQ1) and found that there is a certain duality, in two senses. The first concerns the research evaluation system, which is simultaneously considered a driver (OA publication requirements and data repositories increase OS) and a barrier (conflict of traditional system and

OS values). In this regard, as has occurred in other changing scenarios, there are tensions in the transition to OS. While the OS shift is disruptively moving in many directions (OA, Open Data, OPR, OE, etc.), the current research evaluation frame is anchored in just one. This is emerging as one of the great challenges faced by the plenary implementation of OS.

There is also duality in the current situation of OS at academic institutions, where there is a push from the library (bottom-up support) but not always a clear institutional leadership (top-down action). Librarians are helping to drive OA publishing, managing repositories, advising on Open Data management plans, and negotiating transformative agreements, as well as being key partners in training. In some cases, they can be considered “Open Science champions”, but to win the OS championship, an institutional boost and transversal work are also required. OS needs to be part of strategies and plans, as well as creating more collaborative workflows between different departments or units. In this sense, an interdepartmental training team would be an effective strategy, since libraries are not the only expert trainers. For example, in terms of Open Data, the FAIR4S project³ identified different levels of responsibility and specializations and proposed the contribution of various profiles: data manager, data curator, data librarian, data services engineer, data science engineer, research services developer, research software engineer, and so on. EOSC also added that joining forces with computing departments would be beneficial for both libraries and institutions.

The findings of this study also revealed the level of knowledge of Open Science of researchers and library staff (RQ2). Here, the concept of inequality arises due to the unequal degree of knowledge of the range of OS elements: greater and more generalized regarding AO (researchers and librarians) and Open FAIR data (librarians) but less and more specific regarding the rest of the components of the OS, as they depend on institutional context or personal experience. This last aspect has been related to the concept of need versus interest in the sense that researchers learn OS out of interest and as and when they find themselves obligated to do so (by the requirements of project funders, evaluations of their research, etc). All this dispersion in terms of OS knowledge indicates different levels of maturity in Spanish academic institutions.

Finally, in this paper, we have also discussed training in Open Science delivered in academic libraries and their institutions (RQ3). In this field, we have observed contradictions and new challenges: contradictions because libraries promote, and are often in charge of, OS training but, as the evidence shows, they lack some skills and knowledge. In this sense, training of the trainers is needed. Beyond OA and Open Data, library staff need to build their skills in other OS areas (such as Citizen Science, research integrity, rewards and incentives, open education, etc.), in order to better meet the needs of researchers. This idea of opening up science through

³An EOSCpilot FAIR data stewardship skills for science and academic framework.

different interconnected components is simultaneously directly related to one of the main future challenges for libraries: focusing on new research support services related to the different OS core elements.

Evolving in the various forms of Open Science is key for academic libraries if they want to remain up-to-date and to add value to their research communities. Libraries need to acquire a wide range of skills in order to become more involved in the entire research life cycle. Based on the previous findings, it is crucial that LIS schools and library associations arrange continuous education programmes and training in OS in order to improve knowledge of all the elements of the OS ecosystem. In addition, taking advantage of the fact that more areas of OS are currently being addressed within LERU institutions, libraries now have a great opportunity and an important role to play by developing new services and infrastructures aligned with the global Open Science landscape. One final note to bear in mind: since OS is a complex and multi-dimensional process of transition, such evolution should take years to effect, so libraries should have enough room to carve out their own path.

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References

- Abadal, E. (2021). Ciencia abierta: Un modelo con piezas por encajar. *Arbor*, 197(799). doi: 10.3989/arbor.2021.799003.
- Abadal, E., & Anglada, L. (2020). Ciencia abierta: Cómo han evolucionado la denominación y el concepto. *Anales de Documentación*, 23(1), Article 1. doi: 10.6018/analesdoc.378171.
- Anglada, L., & Abadal, E. (2018). Qué es la ciencia abierta. *Anuario ThinkEPI*, 12, 292. doi: 10.3145/thinkepi.2018.43.
- Anglada, L., Borrego, A., & Abadal, E. (2020). Qué transforman los acuerdos transformativos. *Anuario ThinkEPI*, 14. doi: 10.3145/thinkepi.2020.e14e04.
- Ashley, K., de Vries, J., Swiatek, C., Clavel, K., Meyer, T., & Graver Møving, H. (2018, December). *EOSCpilot & LIBER Webinar: Skills and Training in Open Science and the EOSC ecosystem*. doi: 10.5281/zenodo.2247650.
- Ashiq, M., & Warraich, N.F. (2022). Librarian's perception on data librarianship core concepts: A survey of motivational factors, challenges, skills and appropriate trainings platforms. *Library Hi Tech* (ahead-of-print). doi: 10.1108/LHT-12-2021-0487.
- Ayris, P. (2017). The importance of European collaborations to support open science and digital library development. *LIBER Quarterly*, 26(4), 244-259. doi: 10.18352/lq.10147.
- Ayris, P., Bernal, I., Cavalli, V., Dorch, B., Frey, J., Hallik, M., Hormia-Poutanen, K., Labastida, I., MacColl, J., Ponsati Obiols, A., Sacchi, S., Scholze, F., Schmidt, B., Smit, A., Sofronijevic, A., Stojanovski, J., Svoboda, M., Tsakonas, G., van Otegem, M., & Horstmann, W. (2018a). *LIBER Open Science Roadmap*. doi: 10.5281/zenodo.1303002.
- Ayris, P., López de San Román, A., Maes, K., & Labastida, I. (2018b). *Open Science and its role in universities: a roadmap for cultural change*. LERU Advice paper 24. <https://www.leru.org/files/LERU-AP24-Open-Science-full-paper.pdf>.

- Ayris, P., & Ignat, T. (2018). Defining the role of libraries in the Open Science landscape: A reflection on current European practice. *Open Information Science*, 2(1), 1-22. doi: 10.1515/opis-2018-0001.
- Ayris, P. (2021). *Implementing Open Science. Note from the League of European Research Universities*. <https://www.leru.org/files/Implementing-open-science.pdf>.
- Bahlai, C., Bartlett, L.J., Burgio, K.R., Fournier, A.M.V., Keiser, C.N., Poisot, T., & Whitney, K.S. (2019). *Open science isn't always open to all scientists*. doi: 10.1511/2019.107.2.78.
- Bartling, S., & Friesike, S. (2014). Towards Another Scientific Revolution. In S. Bartling & S. Friesike (Eds.), *Opening Science*. Springer Verlag. pp. 3-15. doi: 10.1007/978-3-319-00026-8_1.
- Bezjak, S., Clyburne-Sherin, A., Conzett, P., Fernandes, P., Görögh, E., Helbig, K., Kramer, B., Labastida, I., Niemeyer, K., Psomopoulos, F., Ross-Hellauer, T., Schneider, R., Tennant, J., Verbakel, E., Brinken, H., & Heller, L. (2018). *Open science training handbook*. doi: 10.5281/ZENODO.1212496.
- Bishop, B.W., Collier, H.R., Orehek, A.M., & Ihli, M. (2021). Potential roles for science librarians in research data management: A gap analysis. *Issues in Science and Technology Librarianship*, 98. doi: 10.29173/ISTL2602.
- Boté, J.-J., & Termens, M. (2019). Reusing data technical and ethical challenges. *DESIDOC Journal of Library & Information Technology*, 39(06). doi: 10.14429/djlit.39.06.14807.
- Boté-Vericad, J.-J. (2022). *Integrating mixed methods to analyse information behaviour in the use of educational videos in higher education*. [Doctoral dissertation, Universität Hildesheim]. Hildok. doi: 10.25528/141.
- Boté-Vericad, J.-J., & Healy, S. (2022). *Academic libraries and research data management. A systematic review*. *Vjesnik Bibliotekara Hrvatske*. doi: 10.30754/vbh.65.3.1016.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. doi: 10.1191/1478088706qp063oa.
- Brinken, H., & Swiatek, C. (2018, July 9). Let's build the skills! LIBER Digital Skills WG 2018 workshop. doi: 10.5281/zenodo.1308131.
- Cabello-Valdés, C., Esposito, F., Kaunismaa, E., Maas, K., McAllister, D., Metcalfe, J., O'Carroll, C., Rentier, B., & Vandeveld, K. (2017). *Evaluation of research careers fully acknowledging open science practices: rewards, incentives and/or recognition for researchers practicing open science*. Luxembourg: Publications Office of the European Union. ISBN: 978 92 79705151.
- Carballo-García, A., & Boté-Vericad, J.-J. (2022). Fair data: History and present context. *Central European Journal of Educational Research*, 4(2), 45-53. doi: 10.37441/cejrer/2022/4/2/11379.
- Carole, L., Cachard, P., Dupuis, M., & Froment, B. (2021). *La place des bibliothèques universitaires dans le développement de la science ouverte*. Ministère de l'Enseignement supérieur et de la Recherche. IGESR Report, 22. <https://www.enseignementsup-recherche.gouv.fr/fr/la-place-des-bibliotheques-universitaires-dans-le-developpement-de-la-science-ouverte-47671>.
- Cox, A., & Abbott, P. (2021). Librarians' perceptions of the challenges for researchers in rwanda and the potential of open scholarship. *Libri*, 71(2), 93-107. doi: 10.1515/libri-2020-0036.
- Cox, A.M., Kennan, M.A., Lyon, L., & Pinfield, S. (2017). Developments in research data management in academic libraries: Towards an understanding of research data service maturity. *Journal of the Association for Information Science and Technology*, 68(9), 2182-2200. doi: 10.1002/asi.23781.
- CRUE Universidades españolas. (2019). *Compromisos de las universidades ante la Open Science*. https://www.crue.org/wp-content/uploads/2020/02/2019.02.20-Compromisos-CRUE_OPENSCIENCE-VF.pdf.
- Delgado-López-Cózar, E., Ràfols, I., & Abadal, E. (2021). Letter: A call for a radical change in research evaluation in Spain. *El Profesional de La Información*, e300309. doi: 10.3145/epi.2021.may.09.
- Engelhardt, C., Biernacka, K., Coffey, A., Cornet, R., Danciu, A., Demchenko, Y., Downes, S., Erdmann, C., Garbuglia, F., Germer, K., Helbig, K., Hellström, M., Hettne, K., Hibbert, D., Jetten, M., Karimova, Y., Kryger, H., Karsten, K., Mari Elisa, L., & Zhou, B. (2022). *D7.4 How to be FAIR with your data. A teaching and training handbook for higher education institutions* (V1.2.1). doi: 10.5281/zenodo.6674301.
- Mendez, E., & Lawrence, R. (2020). *Progress on open science: towards a shared research knowledge system: final report of the open science policy platform*. European Commission Publications Office. doi: 10.2777/00139.

- European Commission. (2019). *Open Science Factsheet. The eight ambitions of Open Science*. https://research-and-innovation.ec.europa.eu/system/files/2019-12/ec_rtd_factsheet-open-science_2019.pdf.
- EOSC. (2021). *Workshop Research Libraries, Researchers and the EOSC*. Final Report-March 2021. https://libereurope.eu/wp-content/uploads/2021/12/Liber_EOSC_final-version.pdf.
- Gagliardi, D., Cox, D., & Li, Y. (2015). *Institutional inertia and barriers to the adoption of open science*. Brill. doi: 10.1007/978-94-6300-178-6_6.
- Giustini, D., Read, K.B., Deardorff, A., Federer, L., & Rethlefsen, M.L. (2021). Health sciences librarians' engagement in open science: A scoping review. *Journal of the Medical Library Association*, 109(4). doi: 10.5195/jmla.2021.1256.
- González-Teruel, A., López-Borrull, A., Santos-Hermosa, G., Abad-García, F., Ollé, C., & Serrano-Vicente, R. (2022). Drivers and barriers in the transition to open science: The perspective of stakeholders in the Spanish scientific community. *Profesional de la información*, 31(3). doi: 10.3145/epi.2022.may.05.
- Heise, C., & Pearce, J.M. (2020). From open access to open science: The path from scientific reality to open scientific communication. *SAGE Open*, 10(2), 215824402091590. doi: 10.1177/2158244020915900.
- LIBER. (2021). Citizen Science Skilling for Library Staff, Researchers, and the Public. In Jitka Stilund Hansen (Eds.), *Citizen Science for Research Libraries – A Guide*. doi: 10.25815/hf0m-2a57.
- Krippendorff, K. (2004). *Content analysis: an introduction to its methodology*. Sage.
- Mayring, P. (2010). *Qualitative Inhaltsanalyse. Grundlagen und Techniken*. Beltz Verlag.
- Masona Tapfuma, M., & Geraldine Hoskins, R. (2019). Open science disrupting the status quo in academic libraries: A perspective of Zimbabwe. *The Journal of Academic Librarianship*, 45(4), 406-412. doi: 10.1016/j.acalib.2019.05.005.
- McCaffrey, C., Meyer, T., Riera Quintero, C., Swiatek, C., Marcerou-Ramel, N., & Gillén, C. (2020, March). *Open science skills visualization* [internet]. Zenodo. https://zenodo.org/record/3702401#.Y_x94ZPMI8Y.
- Melero, R., Boté-Vericad, J.-J., & López-Borrull, A. (2022). Perceptions regarding open science appraised by science editors of scholarly publications published in Spain. *Learned Publishing*, 36(2). doi: 10.1002/leap.1511.
- Méndez, E. (2021). Open Science por defecto. La nueva normalidad para la investigación. *Arbor*, 197(799), Article 799. doi: 10.3989/arbor.2021.799002.
- Mons, B., Neylon, C., Velterop, J., Dumontier, M., da Silva Santos, L.O.B., & Wilkinson, M.D. (2017). Cloudy, increasingly FAIR; revisiting the FAIR Data guiding principles for the European Open Science Cloud. *Information Services & Use*, 37(1), 49-56. doi: 10.3233/ISU-170824.
- Nicholas, D., Watkinson, A., Boukacem-Zeghmouri, Rodríguez-Bravo, Xu, J., Abvriah, A., Marzena, S., & Herman, E. (2017). Early career researchers: Scholarly behaviour and the prospect of change. *Learned Publishing*, 30(2), 157-166. doi: 10.1002/leap.1098.
- Norris, E., & O'Connor, D.B. (2019). Science as behaviour: Using a behaviour change approach to increase uptake of open science. *Psychology & Health*, 34(12), 1397-1406. doi: 10.1080/08870446.2019.1679373.
- O'Carroll, C., Hyllseth, B., Rinkse van den, B., Kohl, U., Kamerlin, C., Brennan, N., & O'Neill, G. (2017). *Providing Researchers with the Skills and Competencies They Need to Practise Open Science*. Brussels: European Commission. Directorate-General for Research and Innovation. doi: 10.2777/121253.
- OECD. (2015). Making open science a reality. *OECD Science, Technology and Industry Policy Papers*, 25. Paris: OECD Publishing. doi: 10.1787/5jrs2f963zs1-en.
- Ochoa-Gutiérrez, J., & Uribe-Tirado, A. (2018). Open science and academic library: A systematic literature review. *Iris*, 4(1), 49-69. doi: 10.2139/ssrn.3483731.
- Ogunbeni, J.I., Obiamalu, A.R., Ssemambo, S., & Bazibu, C.M. (2018). The roles of academic libraries in propagating open science: A qualitative literature review. *Information Development*, 34(2), 113-121. doi: 10.1177/0266666916678444.
- Pontika, N., Knoth, P., Cancellieri, M., & Pearce, S. (2015). Fostering open science to research using a taxonomy and an eLearning portal. *Proceedings of the 15th International Conference on Knowledge Technologies and Data-Driven Business*, pp. 1-8. doi: 10.1145/2809563.2809571.
- Puccinelli, R., Reggiani, L., Saccone, M., & Truffelli, L. (2020). Open educational resources and library

- & information science: Towards a common framework for methodological approaches and technical solutions. *Grey Journal*, 16(3), 161-171.
- Rath, M., & Wang, P. (2017). Open Peer Review in the Era of Open Science: A Pilot Study of Researchers' Perceptions. *2017 ACM/IEEE Joint Conference on Digital Libraries (JCDL)*, pp. 1-2. doi: 10.1109/JCDL.2017.7991608.
- Redkina, N.S. (2022). The Library in the Information Ecosystem of Open Science. *Scientific and Technical Information Processing*, 48(4), 239-247. doi: 10.3103/S0147688221040043.
- Revez, J. (2018). Opening the heart of science: A review of the changing roles of research libraries. *Publications*, 6, 9. doi: 10.3390/publications6010009.
- Rice, R. (2019). Unterstützung von Forschungsdatenmanagement und offener Wissenschaft in wissenschaftlichen Bibliotheken: die Sicht eines Data Librarians. *Mitteilungen Der Vereinigung Österreichischer Bibliothekarinnen Und Bibliothekare*, 72(2), 263-273. doi: 10.31263/voebm.v72i2.3303.
- Saarti, J., Rosti, T., & Silvennoinen-Kuikka, H. (2020). Implementing Open Science policies into library processes – case study of the University of Eastern Finland library. *LIBER Quarterly*, 30(1), 1-20. doi: 10.18352/lq.10336.
- Santos Hermosa, G. (2019). L'educació oberta a Europa: avenços, integració amb la ciència oberta i rol bibliotecari. *BiD: textos universitaris de biblioteconomia i documentació*, núm. 43. doi: 10.1344/BiD2019.43.14.
- Santos-Hermosa, G., Estupinyà, E., Nonó-Rius, B., Paris-Folch, L., & Prats-Prat, J. (2020). Open educational resources (OER) in the Spanish universities. *Profesional de la informació*, 29(6). doi: 10.3145/epi.2020.nov.37.
- Santos-Hermosa, G., Proudman, V., & Corti, P. (2021). *Open Education in European Libraries of Higher Education. 2021 report*. doi: 10.5281/zenodo.5734980.
- Santos-Hermosa, G., & Atenas, J. (2022). Building capacities in open knowledge: Recommendations for library and information science professionals and schools. *Frontiers in Education*, 7. doi: 10.3389/educ.2022.866049.
- Santos-Hermosa, G., & Boté-Vericad, J.-J. (2023). Dataset about the Spanish academic libraries' perceptions of Open Science. Drivers and barriers, level of knowledge and training. doi: 10.34810/data633.
- Sheikh, A. (2017). Faculty awareness, use and attitudes towards scholarly open access: A Pakistani perspective. *Journal of Librarianship and Information Science*, 51(3), 612-628. doi: 10.1177/0961000617742455.
- Scott, R.E., Harrington, C., & Dubnjakovic, A. (2021). Exploring open access practices, attitudes, and policies in academic libraries. *Portal: Libraries and the Academy*, 21(2), 365-388. doi: 10.1353/pla.2021.0020.
- Sultan, M., & Rafiq, M. (2021). Open access information resources and university libraries: Analysis of perceived awareness, challenges, and opportunities. *The Journal of Academic Librarianship*, 47(4), 102367. doi: 10.1016/j.acalib.2021.102367.
- Swiatek, C. (2019). *LIBER Digital Skills Working Group: Case Studies on Open Science Skilling and Training Initiatives in Europe*. doi: 10.5281/zenodo.3901485.
- Swiatek, C., McCaffrey, C., Meyer, T., Svenbro, A., Brinken, H., Egerton, F., & Clavel, K. (2020). *LIBER Open Science Training Methods and Practices Across European Research Libraries – Survey Analysis*. doi: 10.5281/zenodo.3903142.
- Tenopir, C., Rice, N., Allard, S., Baird, L., Borycz, J., Christian, L., Grant, B., Olendorf, R., & Sandusky, R.J. (2020). Data sharing, management, use, and reuse: Practices and perceptions of scientists worldwide. *PLoS ONE*, 15(3): e0229003. doi: 10.1371/journal.pone.0229003.
- Tzanova, S. (2020). Changes in academic libraries in the era of Open Science. *Education for Information*, 36(3), 281-299. doi: 10.3233/EFI-190259.
- UNESCO. (2021). UNESCO Recommendation on Open Science. <https://unesdoc.unesco.org/ark:/48223/pf0000379949.locale=en>.
- van der Werf, T. (2020). *Open Content activities in Library: Same direction, different trajectories. Findings from the 2018 Global OCLC Global Council Survey*. Dublin, OH: OCLC Research. doi: 10.25333/vgmw-ba86.

- Vicente-Saez, R., & Martinez-Fuentes, C. (2018). Open Science Now: A systematic literature review for an integrated definition. *Journal of Business Research*, 88, 428-36. doi: 10.1016/j.jbusres.2017.12.043.
- Wilkinson, M.D., Dumontier, M., Aalbersberg, I.J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J.-W., da Silva Santos, L.B., Bourne, P.E., Bouwman, J., Brookes, A.J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C.T., Finkers, R., & Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*, 3(1), Article 1. doi: 10.1038/sdata.2016.18.
- Wouters, P., Ràfols, I., Oancea, A., Kamerlin, S.C.L., Britt Holbrook, J., Jacob, M., & Schomberg, R. (2019). *Indicator frameworks for fostering open knowledge practices in science and scholarship*. European Commission Publications Office. doi: 10.2777/445286.
- Yu, H.H. (2017). The role of academic libraries in research data service (RDS) provision: Opportunities and challenges. *The Electronic Library*, 35(4), 783-797. doi: 10.1108/EL-10-2016-0233.