Findings from the review "Open Science: training and education at the Library"
[original title: Open Science: træning og uddannelse på biblioteket]

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The review aimed to identify Open Science (OS) services, skills and competencies needed to support the researcher in her interaction with research infrastructure, seen from the European perspective and the (Danish) university library perspective. The purpose was to outline which challenges and possibilities there are for university libraries in their future work with open science, specifically how to identify the competencies needed to provide library services supporting OS.

The review consists of five chapters. Chapter 1 introduces the terms and concepts used throughout the review. OS seen from a European university and research library perspective is discussed in Chapter 2, where ground-breaking roadmaps for competence development such as LIBER (Ayris er al, 2018) and LERU (LERU, 2011; 2013;2016;2018;2020) are presented. In Chapter 3, the conceptual model illustrating the DEFF projects' understanding of services supporting the Open Research Ecosystem is presented. The model focuses on the main phases a researcher, in a research project, goes through. These are defined in the three sequential phases: planning, active research and publishing, with the underlying research activities of data discovery, data management, collecting & creating data, processing data, analyzing data, writing, scholarly communication, data publishing and providing access to research (data). To understand how the services identified in the model can be translated into skill and competence development, in Chapter 4 we analyze existing frameworks for Open Science education and training. This analysis includes the Edison Data Science framework (EDISON CF-DS, 2017), EOSC Skills and Capability Framework (EOSC-SCF, 2018), The Open Science Skills Working Group Report (OSSWGR, 2017) and the matrices and models these three frameworks build on. Finally, in Chapter 5, the findings from the previous chapters are combined in a proposed 7-step model to aid libraries identify the competencies required to provide specific OS support services.

As the review is written in Danish, we present in the following a short summary of the main findings.

Open Science from a European University and University Library perspective

European frameworks emphasize the necessary cultural change that needs to happen (and be accepted) in research practices so that organisations and libraries can provide successful policies and services which support OS. Libraries are thus encouraged to take on the role of "change agents", proactive actors, who are well placed to make the OS revolution happen, for example by kick-starting an academic culture change which favours FAIR data and making FAIR the default for research data (Ayris et al, 2018: 18). In the library's work with researcher support, the governance of open research data via library services should happen in close collaboration and coordination with the university's central administration for information security, GDPR, data-governance and data policies, in compliance with national and institutional data strategies and the specific requirements of research projects. Accordingly, it is not just researchers that need training and education in OS practices but also library staff need training as well, to be able to better meet the needs of the library user who wishes to produce research using OS methods and tools.

Open Science Ecosystem: The projects conceptual model

The roadmaps discussed in the previous section only introduce the challenges and possibilities university libraries are facing in their work in supporting OS. The roadmaps do not reflect the everyday reality individual university libraries operate in or how to operationalize the strategies recommended in the

roadmaps. By combining the general recommendations in the roadmaps with the FOSTER taxonomy[1] for OS, we are able in the review to express the ambiguity of terms depicting OS activities, processes and actors. Hence in the DEFF projects own model and idea catalogue we can present a simplified, manageable lineup of OS services in the local context of Danish University Libraries, informed by FOSTERS previous work on how to consolidate and support OS training support. However, we observed that FOSTER taxonomy has not been updated since 2015 and are aware that important service and areas for strategic development such as FAIR and EOSC are not included in the classification system. Further, the taxonomy is developed on a higher level supporting the European OS agenda rather than the local (Danish) one, which is why we further adapted the taxonomy in our own model with the aim to explicitly tailor the taxonomy to local and national policies and strategies requiring the support of specific OS practices in university libraries, fig. 1.
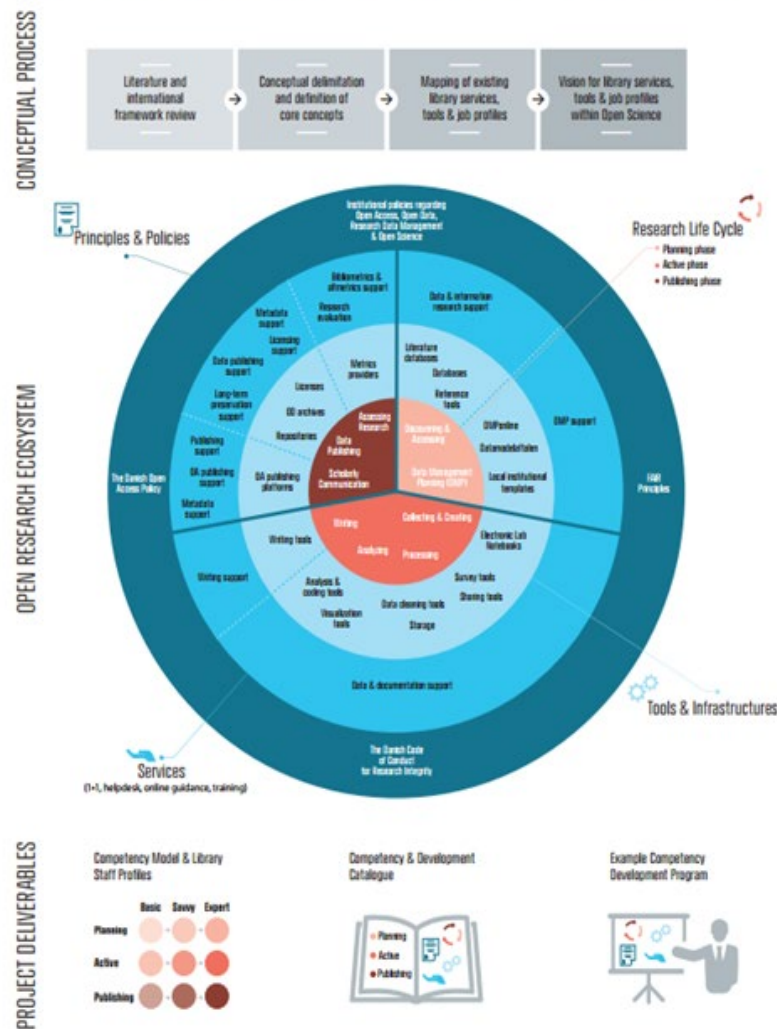

Figure 1: OS services and skills at Danish University Libraries

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[1] FOSTER (2014-2016) and FOSTER+ (2017-2019) are two H2020 projects, with the aim to develop OS training for Euorpean Research (**F**acilitate **O**pen **S**cience **T**raining for **E**uropean **R**esearch): https://www.fosteropenscience.eu/foster

In the model, Fig 1, the user is depicted in the center of the research lifecycle, which consists of concentric circles. Important to note, is that the user is placed at the center of service development (the segments in three shades of pink). The user moves through three different phases of project development (planning, active research and publishing) where a multitude of actions and interactions require support. These activities occur in the context of institutional and national principles and policies for Open Science, Open Access publishing, Open Data, FAIR data, Data Management and importantly the Danish Code of Conduct for Research Integrity (the outer dark blue circle). In the medium blue circle, the different actors involved in OS processes and support are depicted (data and documentation support, IT support, metadata support, publishing support, etc) indicating that good OS support is a team effort and the library cannot lift these important services alone. In the light blue circle, closet to the user, are the front end services, infrastructures and tools available to the user. Getting to know and understanding the user and her needs requires the ability of the service provider to undertake user studies, gap-analyses, promotion activities and networking. We found these skills to be under-valued in both the road-maps and the FOSTER taxonomy.

The project's model model has its limitations. Firstly, the static representation of the research process, where in reality any interactions in the phases of a research process are dynamic and iterative. Secondly, the model does not mediate how to translate the identified OS services into relevant competencies and skills. Therefore, it was imperative in the review to analyze competence development frameworks. Knowledge gained from this analysis will enable us to link services to skill requirement.

Frameworks for OS education and training: linking services to skills

A comprehensive overview of the analysis of frameworks for competence development undertaken in the review is presented in Appendix 1 [in English]. This analysis includes the Edison Data Science framework (EDISON CF-DS, 2017), EOSC Skills and Capability Framework (EOSC-SCF, 2018), The Open Science Skills Working Group Report (OSSWGR, 2017) and the project's own model, Fig. 2.
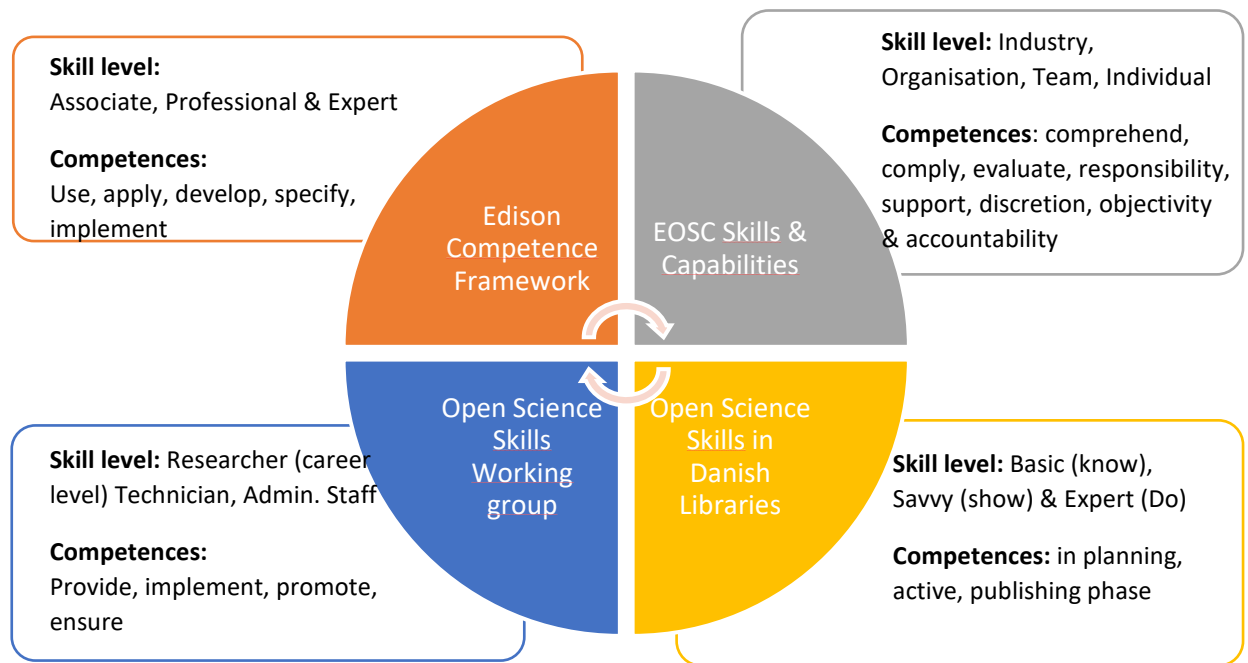

Skill level:
Associate, Professional & Expert

Competences:
Use, apply, develop, specify, implement

Skill level: Industry, Organisation, Team, Individual

Competences: comprehend, comply, evaluate, responsibility, support, discretion, objectivity & accountability

Edison Competence Framework

EOSC Skills & Capabilities

Open Science Skills Working group

Open Science Skills in Danish Libraries

Skill level: Researcher (career level) Technician, Admin. Staff

Competences:
Provide, implement, promote, ensure

Skill level: Basic (know), Savvy (show) & Expert (Do)

Competences: in planning, active, publishing phase

Figure 2: Overview of skill levels and competencies in Edison CF, EOSC, OSSWG and the project's own model

The frameworks describe which competences researchers, support staff and data scientists require to work in a responsible and sustainable manner with OS. Each framework has its own working definitions of OS, which activities that require support and on who in the organization should provide support and on which level. Accordingly, a high-level observation from the analysis is that in operationalizing OS activities, services and competence development programmes should incorporate a standardized concept definition and qualification framework to increase the transparency of qualifications and their relationships to each other. Together clear definitions and expectations to skills, training programs and qualifications will act as a common reference point and promote the culture of life-long learning needed to provide innovative and relevant OS support.

As the frameworks are so very different a direct comparison is not possible, however we were able to identify recurrent themes and commonalities across the frameworks that we concluded to be the generic minimum requirement for OS services, Table 1. Across all frameworks, domain expertise and didactic skills were emphasized as essential for successful research support as requirements to scientific production, data management, scientific communication, policy and learning-styles are different from domain to domain. Clearly, there are countless services that can be built on top of the basic service package described in Table 1, for inspiration please refer to Appendix 1.

Support Service	Competencies
Planning & Design	data management, metadata, compliance, repositories& database design
Capture & Process	workflow setup, database management/improvement, file name & organisation
Integrate & Analyze	-
Appraise & Preserve	documentation for reproducibility, compliance
Publish & Release	licences, sharing via OA platforms, publisher & funder requirements
Expose & Discover	visualization, presentation, searching
Govern & Assess	research strategy, open vision, advocation FAIR, research integrity & security
Scope & Ressource	costing af data management & preservation, funding and cloud management
Advize & Enable	engagement with stakeholders, contribution to OS networks, standards and bodies, training services and guides in open methods.

Table 1: generic OS services

Note: The service "integrate & analyze" does not have descriptions of generic competencies. This is because no commonalities were found across the frameworks. Required competencies depend on the local context and research culture. For example services supporting Integrate & Analyze can include knowledge of domain relevant methodologies in statistics, data transformation, data mining, NLP and machine learning amongst many other possibilities.

The ability to mediate OS is identified as centrally important for successful research support, as education in OS methods, tools and extended OS support services will not guarantee engagement of the library user. Further, competence development and training will be less effective if it is not standardized, credited and presented as part of a cohesive, coordinated policy that is supported by the leaders of the library and the university. OS Research support needs to be offered on different levels across the organisation to develop and maintain a OS culture and promote OS practices. The library is emphasized in the frameworks as having a central role in OS support and therefore the competence and skill development of librarians, even though these skills are not discussed in detail in any of the frameworks, are just as important as the researcher's skills if we are to build successful OS practices and services.

From research support librarians to data support professionals

OS support has led to the need for a new form for research support at the library: data support professionals. Data support professionals build further on traditional library expertise in knowledge preservation, the organization of knowledge, publishing and source criticism, and contribute with ne knowledge in how data is managed, shared, stored and published responsibly throughout the lifecycle of a research project and in the short and long term. Data support professional do not necessarily have a library science background, but rather domain and research knowledge from previous work/life experiences (Rice and Southall, 2016). This has led to strategic employment at university libraries, where their background knowledge and experience are used to target and promote OS services across the university. The main difference between "traditional" research support librarians and data support professionals at the library, is the expectation that they work with processes where data is used to produced information rather than working with knowledge that has already been published (Ohaji, Chawner and Yoong, 2019). There is not a "one-size-fits-all" solution to the profile of a data support professional, but the foundation is:

- Specialist and domain knowledge is seen as a competencies that benefits OS services, including technical and methodological knowledge & skills, domain specific knowledge, skills and knowledge in how to teach, communicate, and networking.
- Skills and knowledge in organizational strategies and data policies
- Skills in collaboration and project management
- Basic technical skills in working with data and technologies
- Basic soft skills in mediating the rationale for OS and supporting change in research culture
- Commitment to continuous learning throughout their career in researcher support

To be able to create services that support the dynamic development of OS, research support should be organized to manage change and innovation. Therefore, the project recommends a team approach to research support, where the collective knowledge and skills of the support professionals are used to inform strategic support development and support responsibles. When research support is seen as team-work, the library can beneficially exploit the strengths and weakness of library staff in service development – teams can be made up of librarians distributed across the university landscape who do not usually work together, or include team members from other departments at the university such as administrative staff, IT support staff and fund-raisers. Thus teams consists of members with hybrid profiles, and not all memebers of the team have the same level of expertise. A data support professional can then be part of many different teams, and contribute with knowledge at a different level of expertise on each team. When the dependence of a service on an individual's expertise is eliminated, the service becomes much more stable,

mobile and sustainable in the long-term. A hybrid approach such as this, has the possibility to create a greater incitement for the individual staff person at the library to get involved with researcher support.

From services to competencies: A 7-step model

The challenge is to align services with local requirements and research culture, and the extent the library can react quickly enough with a pallet of dynamic services that support the strategic development of the university it serves. Some needs for support services develop quickly, while others such as policy development and implementation develop at a much slower rate. The library's services and competencies find themselves at the tipping point between supporting existing research cultures and predicting which methods and tools they need to invest in over the coming years. Central for this review is how to strategically develop skills and competencies that will support a rational portfolio of services. To conclude the review, we attempted to operationalize the gathered theoretical and empirical knowledge in a strategic tool to identify services, competencies and skills.

The 7- step model, Figure 3, includes a qualification framework to rationalize and qualify expectations to skill levels. Services, competencies and skills are illustrated uses cases. Standard terminology from Blooms Taxonomy and the Danish Qualification Framework for Life-long Learning are used to describe expectations to learning outcomes and competence levels. An example is presented at the end of this chapter.
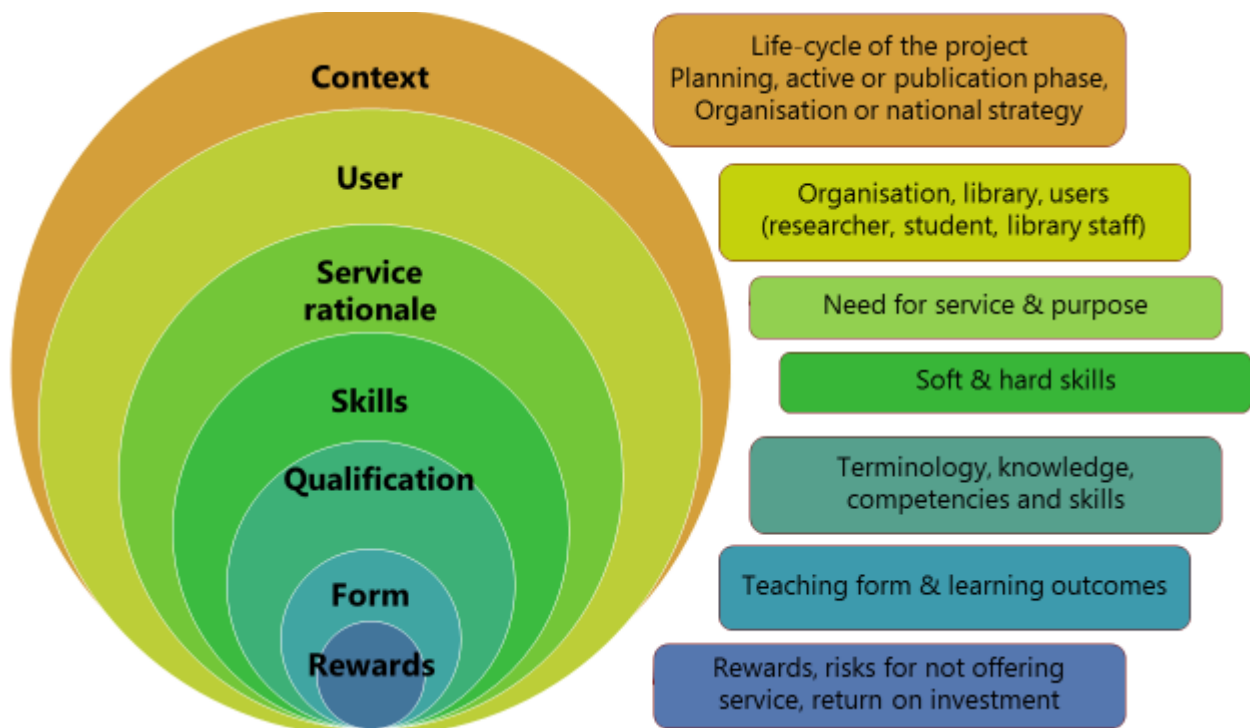

Figure 3: 7-step model for rationalized services, competencies and skills

Step 1: Define the context – this could be the university's overarching research strategy or a research group trying to satisfy a particular funding mandate. The context sets the parameters for the services, competencies and skills.

Step 2: The user – Identify who needs the service and why. Is the user an entire organization, a department or set of individuals with common characteristics? Each group has different needs, knowledge, skills and expectations to a service.

Step 3: The rationale for the service – based on knowledge of potential users of the service and their needs, define which activities the service should support, the extent the service intends to build up a capacity within the organization, support a process or provide technical skill support. How will all of the aforementioned inform the aim of the service?

Step 4: Skills – which hard and soft skills are required to support the activities described in step 3?

Step 5: Qualification framework - Link the skill requirements defined in step 4 to a verified qualification framework, not a "home-grown" one. A qualification framework defines what is considered "knowledge", "competence" and "skill" and on what level. A qualification framework enables us to formulate the knowledge, learning outcomes and expectations to skills and competencies using standard terminology that is transferable and understandable across different organizations and even countries. Further, a qualification framework illustrates the progression in competence levels, from what is expected as a basic level to what is expected on an expert level.

Step 6: Form – the appropriate form of service/teaching the skills and competencies described in step 5 can now be designed. Different forms of teaching have different strengths and limitations with regard to different subjects and the learning processes of different participants.

Step 7: Rewards – description of the profits the organization could gain from a potential service/ training programme and risks of NOT holding offering the service/training programme.

All together, the 7 steps provide a service development model that enables a dialogue regarding the rationale for a service and the identification of skills and competencies in the context of use-case scenarios.

Conclusion and recommendations

OS support services require constant development as OS is still itself being developed and professionalized. Consequently, the up-skilling of service providers requires that library leaders and staff are development oriented, adaptable to change and are invested in learning new skills. At all levels of library service, from the information desk to specialist research support at university faculties, knowledge of the affiliated university's OS research policy is an essential minimum.

There are a great amount of potential OS services, actions, tools and methods that researchers can use (Appendix 1), too many for the library to support every single one. Thus, a strategic approach to service and skills development is recommended, one that complements the university to which the library is affiliated. Strategic development requires a collaborative approach, where the library is seen as a strong sparring partner (agent of change) with the university and with the users of the library.

For the library to be able to fulfill the mission as agent of change, steps towards successful service and competence development could be:

- Identify which services supporting the OS research lifecycle are essential for the user, library and organization and thereafter identify which type of competencies are needed to support these services (soft or hard). Identify on which level there is need for support – on a generic level or expert level.
- Nurture interest and curiosity in OS at the university and in the library. Communicate use cases and success stories with OS, focusing on the impact the research product has had. This will create momentum and continue nurturing the interest in OS culture and practices. Support continuous learning and up-skilling.
- Use a "step by step" approach to competence development, supported by a qualification framework for standardize expectations to knowledge and skills in the development of training programmes, participants in training programmes and across organizational boundaries. Suggested in the review as a 7-step model.
- Promote and implement core OS services at the same time the university discusses and implements its OS strategy. Forward thinking/planning is key.
- God guidance and sparring about OS must not solely focus on technologies and policy, but also the context in which these changes OS practices executed.
- Relevant and strategic competence development should be aligned with strategies and activities in the university. There should be less focus on theories and abstract concepts and more focus on the practicalities and concrete cases. Most important, and an area librarians already are experts in, is mediation, user-studies, communication and collaboration.

The greatest challenge to the use and success of services supporting OS practices is the lack of competencies, motivation and resources among users, libraries and leaders. Not all library staff are motivated or have the necessary technical competencies to use and teach digital tools to support and promote OS. Therefore, we recommend educating library staff with hybrid profiles combined with a working knowledge of the university and its OS strategies. A librarian can have different levels of competencies (basic, savvy, expert) in different areas of researcher support. Together, with other actors at the university, the library provides a team with a broad pallet of knowledge and services.

An example of the 7-step model of strategic service and competence development

Step 1: Context - How can researcher support at the libary support publication of data from H2020 RIA actions?

Step 2: User - Research groups under the requirement of the H2020 pilot on Open Research Data w.r.t. H2020 Annotated Grant Agreement (AGA)

Step 3: The rationale for the service – Participants in H2020 funding applications need help understanding and fulfilling the requirements to administering and publishing data openly. The university needs to be able to recommend repositories in which researchers can publish their data yet still adhere to the requirement of the Open Data Pilot.

Step 4: Skills-

        Hard: PID, metadata, Licenses, Openness & FAIR

        Soft: how to teach (didactic & pedagogy), H2020 & OPENAIRE compliance

Step 5: Qualification framework (is this example we use the Danish Qualification Framework for lifelong learning: https://ufm.dk/en/education/recognition-and-transparency/transparency-tools/qualifications-frameworks?set_language=en&cl=en

Level (project model)	Knowledge	Skills	Competences
Basic	Basic knowledge on AGA H2020 and where to find information on it.	point to resources w.r.t. H2020 Data management policy, GDPR, ethics, copyright, Creative Commons etc.	Direct the researcher to Data management and local H2020 support services
Savvy	Knowledge about rights and requirements to publishing H2020 project data. Knowledge about challenges in publishing sensitive data and the benefits of meta-data descriptions. Identify potential issues that need expert guidance.	Teach in the practical application of licenses and PIDs in H2020 projects. Provide advice on Metadata Enrich a metadata template with H2020 metadata and PIDs.	Compare and provide guidance regarding different types of licenses (Creative Commons, MIT, GNU) and metadata standards. Guide the researchers in the expectations there are to FAIR In H2020 and other relevant research policies.

Expert	Knowledge on quality assurance of data regarding the FAIR principles and open standards in H2020, including domain specific metadata standards, ensuring compliance and relevant H2020, university and national policies. Kowledge of domain specific onthologies.	Guide the researcher's choice of data archive, repository etc. and questions regarding copyright, responsibilities and accountability when publishing data, PIDs and metadata. Teach the FAIR-principles(FAIR for machines, AI and the relation between PIDs, metadata and interoperability)	Council researchers during their research project. Use tools to manage data, including sensitive data, including how to pseudo-anonymize and anonymize data correctly. Collaborate with researchers to develop taxonomies and open linked data.

Step 6: Form-

- Half yearly seminars to up-date knowledge of H2020 administration and calls, FAIR, complaicne and knowledge sharing experiences.
- Online tutorials in licensing, PIDs and metadata that increases the visibility of data in repositories.
- Bootcamps for support professionals providing expert support in metadata and open (FAIR) data practices.

Step 7: Rewards – Research support becomes a knowledgable and quality ressource for researchers in H2020 projects. The university's datasets become more visable in respositories and as a result are used more. The university's strategy to work openly and FAIR is supported.

The risks involved in NOT providing the service, are that researchers in H2020 projects do not adhere to the rules on publishing data openly. They may not fulling understand the requirements to open and FAIR data and discover their responsibilities too late in the project. The result is a lot of extra identifying up work, documentation and administration that is both demanding in time and other resources. The research project can ultimately be compromised.

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Frameworks

D7.3: Skills and Capability Framework
Ophav: EOSC
Version: V1.0 2018-07-04
Link: https://www.eoscpilot.eu/sites/default/files/eoscpilot-d7.3.pdf

Edison Data Science Framework Release 2: Part 1. Data Science Competence Framework (CF-DS)
Ophav: Demchenko, Y., Belloum, A., Manieri, A., Wiktorski, T., Wouter, L., Spekschoor, E.
Version: Release 2, v0.8, juli 2017
Link: https://zenodo.org/record/1044346/files/EDISON_CF-DS-release2-v08.pdf

Providing researchers with the skills and competencies they need to practice Open Science
Ophav: Open Science Skills Working Group
Version: Juli 2017
Link: https://ec.europa.eu/research/openscience/pdf/os_skills_wgreport_final.pdf

Open Research Eco-System (project's own model):
Presented as a poster "Open Science Skills in Danish Research Libraries", at Digital Infrastructures for Research 2018: https://zenodo.org/record/1478553

Other References

Rice, R., og Southall, J. (2016). The Data Librarian's Handbook. Facet Publishing

Ohaji, I.K., Chawner, B., and Yoong, P. (2019) The role of the data librarian in academic and research libraries. *Information Research,* vol.24(4). http://informationr.net/ir/24-4/paper844.html

Appendix 1: Tables of analyses

https://docs.google.**com**/document/d/1h3NnqHLy5BnZJutuJVbBmrBTeluXKYmqUwz-UFq-SOs/edit?usp=sharing

Appendix 1 presents:

1) an overview of the EOSC Skills and Capability Framework, Edison Data Science Framework, Open Science Skills Working Group and the projects own Open Research Eco-System, including focus areas for competence development, support services.
2) competence and skill levels described in the above frameworks and project's own model
3) A taxonomy of researchers' interaction with the life-cycle of a research project and the OS tools they use.