Chapter

FAIR and Open Research Metadata as Leverage for Digital Libraries: The Flemish Case

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Abstract

Since the advent of the digital age, academic libraries have been transforming from traditional libraries to digital libraries. While digitisation of published materials has been taking place in most libraries, research data is not yet a common good. However, in an era where the Open Science movement affectuates the modus operandi of the entire research ecosystem, it is paramount for digital libraries to include information on other digital objects such as research data. In fact, FAIR and Open research (meta) data can truly act as a leverage for digital libraries and broaden the scope of the library from a place for content consumption to a place for content creation. In order to take on this role, digital libraries must cooperate with ICT and the research community to ensure that the infrastructure is in place to store research (meta)data and that the librarians have the digital skill set for handling FAIR and Open research (meta) data. Throughout the chapter, we will elaborate on the essentials for creating a digital repository, with emphasis on the underlying metadata scheme using the Flemish application profile for research data as example. In addition, we will highlight the essential roles for operating digital libraries containing research data.

Keywords: Digital libraries, Open Science, metadata model for research data, digital skills, FAIR and Open Data

1. Introduction

Over the past decades, many academic libraries have been actively involved in building institutional repositories that comprise books, papers, theses and other works which can be digitised or that were born digital. This offers many advantages in terms of the ease and speed with which users can access the available content. As such, digital libraries are losing their physical boundaries, also in terms of storage space, and can offer a round the clock availability. In addition, academic libraries allow for an easier search through the available content and thus re-use of the knowledge contained. Altogether, this has provided academic libraries with more possibilities to make their content available to the general public, in accordance with the Open Access [1] principles unless conditions are imposed by the publishers that limit access rights. In this way, digital libraries have accelerated the Open Science movement, which in essence started already in the 17th century with the establishment of the academic journal, as a means to share resources and scientific knowledge upon societal demand [2, 3]. Although Open Access is one of the best known components of Open Science, the latter concept in essence comprises all

methods to disseminate scientific research results to the public. Thus, Open Science also includes Open Data, Open Research Software/Source, Open Evaluation, Open Educational Resources, Open Advocacy and Citizen Science.

Over the past years, research performing and funding organisations have particularly stressed the importance of Open Data, which aims to make research data freely available to everyone to use and republish, without any restrictions [4]. This movement has urged academic libraries in collaboration with ICT and the research community to develop a new component within their institutional repositories that allows for the storage and retrieval of research (meta)data for the general public, unless conditions are imposed that limit access rights, similarly to Open Access. Moreover, this new role of the academic library also urges the development of digital skills for librarians in order to ensure that they can assist researchers to make the (meta)data FAIR, i.e. findable, accessible, interoperable and reusable, and whenever possible open. This chapter provides an overview of the transformation of academic libraries to act as a leverage for FAIR and Open research metadata, with respect to the research information systems and repositories as well as the skillset of the librarians.

2. Digital repositories and Open Data

The role of digital libraries in Open Science is well recognised and has been endorsed by several international organisations and stakeholders. In 2012, the European Commission extensively promoted the role of libraries in the Commission's recommendation on Access to and Preservation of Scientific Information in Europe [5]. In 2015, the Organisation for Economic Co-operation and Development (OECD) further emphasised the role of the libraries, repositories and data centers as key actors on Open Science together with researchers, government ministries, funding agencies, universities and public research institutes, private non-profit organisations and foundations, private scientific publishers, businesses and supra-national entities [6]. In concrete, the OECD-report assigned the role of enablers to libraries, thereby describing it the libraries '*role to ensure the preservation, curation, publication and dissemination of digital scientific materials, including research data*'. In addition, the OECD-report pointed towards libraries and repositories to constitute the physical infrastructure that allows researchers to share and (re)use digital scientific material, including research data. Since 2016, the European Commission has increasingly invested in Open Science, and organises its policy according to eight ambitions (**Table 1**) [7].

In order to realise these strategic goals, the European Commission has been taking initiatives that allow for defining the general framework for future strategic research, development and innovation activities in relation to Open Science in general, and

- FAIR and open data should become the default for the results of EU-funded scientific research
- the European Open Science Cloud (EOSC), a federated ecosystem of research data infrastructures, should allow for the sharing and processing of research data across borders and scientific domains
- the development of new metrics for measuring Open Science practices
- the development of Open scholarly communication
- the inclusion of reward systems that recognise Open Science practices
- the investment in digital skills that enable FAIR and Open Science
- the emphasis on research integrity and the inclusion of the general public in Citizen Science

Table 1.
The eight ambitions of Open Science, as defined by the European Commission [7].

the European Open Science Cloud in particular. The resulting Strategic Research and Innovation Agenda (SRIA) of the European Open Science Cloud [8] further stresses the role of research libraries as one of the 6 major stakeholders in developing and implementing EOSC. Throughout the report, digital libraries and research infrastructures are seen as the cornerstones for EOSC, a federated system of data infrastructures. Although the importance of digital libraries is obvious, the reports also provides insights in challenges and boundary conditions for all stakeholders. In what follows, we will focus on what applies for digital libraries in particular.

2.1 Digital repositories as infrastructures for research (meta)data

Many academic libraries have been actively involved in building an institutional repository that makes research output from their affiliated researchers findable, accessible, interoperable and reusable. This is realised through library catalogues and other systems that ensure the storage, management, re-use and curation of hardcopy and digital materials. In order to facilitate these functionalities, digital libraries have to take into account software, which focuses on the preservation, organisation and search functionality on the library's content. Until now, many software solutions have been developed, either as an Open Source solution or proprietary, that all store metadata, i.e. descriptive information on the digital objects contained in the repository. While the metadata and ontologies on research publications have been developed together with research-related metadata (on researchers, projects, organisations, equipment, etc...) largely in the research information community since the 1980s, the metadata and ontologies on research data have grown organically in (sub)disciplinary or geographically spread (sub)communities, which has resulted in a wide variety of schemes available. A manually curated resource on metadata standards for research data is the FAIRsharing.org initiative, which currently provides information on 72 metadata standards, in addition to other standards on thesauri, markup languages, ... (dd 2021-02-21). This high number of metadata standards urges the need for the development of a governance structure to coordinate the work on metadata and ontologies for research data.

2.1.1 Research data and the Flemish Research Information Space

In Flanders, Belgium, the Expertise Centre for Research & Development Monitoring (ECOOM)-Hasselt, was contracted to coordinate the creation of a semantically described, generic metadata model for research data. This metadata model will be integrated by the Flemish institutional repositories that provide information to the Flemish Research Information Space (FRIS), an online platform and current research information system (CRIS) governed by the Department Economy, Sciences and Innovation (EWI) of the Flemish government. In addition, FRIS makes Flemish research information publicly available to all stakeholders in science, economy and innovation [9, 10], and will in the (near) future connect with EOSC.

Currently, the FRIS-portal (researchportal.be) contains information on more than 85.800 researchers, 2500 research organisations, 42800 research projects and 457900 publications (**Figure 1**). This information is provided by the Flemish research universities, higher education colleges, strategic research centers, research institution in an incremental manner. As a common interchange model, the CERIF standard is being used, which is developed and maintained by euroCRIS [11]. Importantly, all information provided (ex. projects, publications, ...) is semantically described, where the concepts behind the terminology are semantically aligned between all information providers. Using data and classification governance methodologies, one can ensure that the research information delivered to FRIS is uniform and comparable.

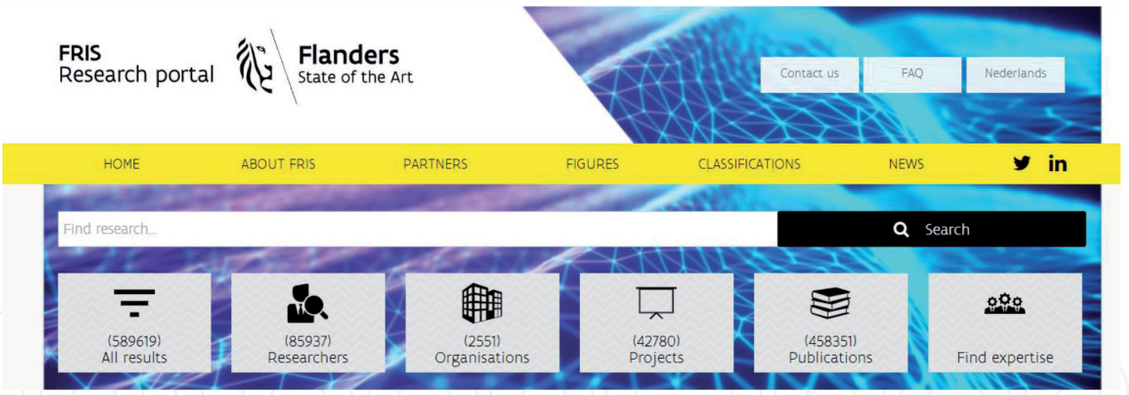

Figure 1.
Flemish Research Information Space, researchportal.be [Accessed 2020-12-23].

In line with the growing importance of research data management, and in particular FAIR and Open Data in Europe, the Flemish Government issued in 2018 two decrees, the Special Research Fund (BOF) Decree [12] and the Industrial Research Fund (IOF) Decree [13], that impose on Flemish universities to provide metadata on research data to FRIS the latest by the end of 2021.

Based on the general European need for a coordinated approach towards metadata models and ontologies, and the requirement of the BOF- and IOF-Decree to deliver metadata on research data by 2021, the Flemish Government contracted ECOOM-Hasselt to develop a generic metadata model for research data that would ensure the uniform delivery of information to FRIS.

2.1.2 The Flemish application profile for research data

In accordance with previously developed metadata models for research information, ECOOM-Hasselt used data governance as a methodology to build a semantically described metadata model for research data. Data governance comprises the specification of decision rights and an accountability framework that encourages desirable behaviour in the creation, storage, use, archival and disposal of (research) data [14]. In addition, it includes the processes, roles and standards that ensure the correct use of (research) data by facilitating the incorporation of explicit semantic definitions and, where required concordance table to other metadata models for research data.

In order to apply the data governance methodology, a working group was composed with participation of experts on FRIS from the Department EWI as well as experts on research data (models) from the Flemish research institutions that provide information to FRIS. This group was termed the Flemish Open Science Board (FOSB) working group Metadata & standardisation and in fact is one of the three working groups under the FOSB that unites all Flemish stakeholders in a shared vision for the future with regards to Open Science and the EOSC Association. The FOSB WG Metadata & standardisation first inventoried existing, yet generic metadata models for research data (ex. DataCite [15], re3data [16], ...) and examined their scope, their uptake in the European research ecosystem as well as their use purpose. Based on this analysis, the WG decided to build an application profile for the Flemish research institutions based upon DataCite's Metadata scheme 4.3, a standard that also has been adopted by OpenAIRE, and which was released on August 16th, 2019 [15, 17].

DataCite is an international not-for-profit organisation which aims to improve data findability, accessibility and re-usability through the assignment of persistent identifiers, such as Digital Object Identifiers (DOIs) to datasets and through the development and maintenance of a metadata standard. This metadata standard contains extensive possibilities to describe metadata of research data and,

importantly, the metadata fields have been semantically defined in order to clarify the concepts behind the terminology used. In addition, this standard has already been implemented by several European and international organisations and allows for interoperability. As the FOSB WG Metadata & standardisation was assigned to deliver a metadata scheme that ensures the FAIRness of research (meta)data on FRIS, with a uniform semantic understanding by all information providing institutions in line with the Flemish research context, the WG decided to develop a Flemish application profile based on the DataCite standard. Moreover, some extensions on DataCite's standard were needed to allow the monitoring of indicators on Open Science, including Open Data. Altogether this resulted in the establishment of an application profile [18] consisting of metadata fields on 21 properties, out of which 15 originated from DataCite. Three of the original Datacite properties were deduplicated, i.e. Description, Subject and Rights and 3 new properties were defined, i.e. Open format, Legitimate opt-out and FAIR data label, that are directly related to the monitoring of indicators on Open Science in Flanders. Similar to the DataCite standard, the Flemish application profile included an indication on the obligation to provide the information to the FRIS-portal using the values mandatory, mandatory if applicable, required and optional. Furthermore, the semantics as defined by DataCite were refined according to the Flemish context, only when needed. Altogether, this resulted in the creation of the Flemish application profile for research metadata.

2.1.3 Integrating the Flemish application profile into FRIS and digital libraries

As the Flemish application profile for research metadata will be included in FRIS, the FOSB WG Metadata and standardisation also strived to maximally integrate the information on research-related information that is residing in this system as this adds substantially to the FAIRness of the data, while at the same time keeps the administrative burden for research as low as possible according to the 'only-once' principle.

In brief, the WG identified the information on research (meta) data that could be enriched via an elaborated set of additional research-related metadata on researchers, research organisations, projects, publications that are already provided to FRIS by the Flemish research institutions. In addition, some additional metadata fields were added to already existing information objects, such as the addition of a DMP identifier metadata field to the object Project. By integrating the metadata models on existing information objects with the Flemish Application Profile for research metadata, we were able to maximise the reuptake of information already residing in FRIS.

In a next phase, the Flemish information providers have to implement the Flemish application profile for research metadata in their institutional repositories. This not only requires profound knowledge on the institutional repository software, but also knowledge on the institution's own use purposes with regards to the stored (meta)data and the coinciding processes. Indeed, the Flemish institutions are not merely storing the metadata on research data in their institutional repositories just to comply with the BOF/IOF-Decree that obliges them to deliver this information to FRIS. In fact, it is of huge importance for research institutions themselves to manage their data. In 2018, the Flemish universities together with the Flemish Interuniversity Council (VLIR) conducted a survey on current research data management practices at the Flemish universities [19]. The resulting paper stated that '*good data management is not a goal in itself, but rather is the conduit leading to knowledge discovery and innovation, and to subsequent data and knowledge integration and reuse by the community after the data publication process*'. As such, research data management is an essential part of responsible research and innovation and should be included in all research-related processes. Consequently, the implementation of

the Flemish application profile for research metadata must take into account the variety of processes, that might be specific for every research institution involved. Therefore, the implementation of the Flemish application profile for research metadata should be accompanied with business and validation rules that ensure its correct implementation and use. Although a basis rule set will be defined for FRIS, research institutions can decide to make the rules more stringent according to their own needs and processes.

3. Digital skills for FAIR and Open Science

Next to the development of the (meta)data repository component in digital libraries, it goes without saying that librarians also need to have the necessary skills set for handling research (meta)data, including the processes related to research data management. Although this general need for research organisations, including digital libraries, to strategically develop digital skills for FAIR and Open Science is well recognised [20, 21], a survey by Stoy et al. [22] demonstrated that this is not yet a widespread phenomenon and more investments are needed.

In 2020, an EOSC Executive Board Skills & Training Working Group was composed in order to delineate amongst others the minimal skill set for EOSC including specifications for training catalogue(s) [23]. This Working Group identified 10 roles in the EOSC ecosystem, which are important to enable EOSC, and thus FAIR and Open Data. Out of the 10 roles identified by the EOSC Executive Board Skills & Training Working Group, some roles are associated more frequently with digital libraries, for example the data steward/data librarian, data curator and EOSC educator role. Although there may be differences to which kind of roles are applying to specific digital libraries, depending on the organisational structure, we will focus here on these 3 roles and the required skill set.

The data librarian/data steward role concerns the person who prepares and handles FAIR research data and maintains data and metadata. This maintenance includes the preservation and storage of the (meta)data according to the FAIR and CARE (Collective benefit, Authority to control, Responsibility and Ethics) [24] principles and in line with ethical and legal frameworks on data. Thus data librarians in Europe should also be aware of the Responsible Research & Innovation program [25], the Open Science framework of the European Commission, the European General Data Protection Regulation (GDPR) [26], the Nagoya Protocol [27] and the control of trade in dual-use goods (Dual Use products) [28]. In addition, data librarians should develop skills to facilitate the development of the digital library infrastructure, including library services that allow for the easy discovery, curation, preservation and retrieval on the contained digital objects together with ICT and the research community. Finally, data librarians should be acquainted with domain-specific standards and best practices in order to ensure that data can properly take into account the specifics of research disciplines.

The data curator role concerns the person who has a broad overview on the content of the institutional repository and who ensures the long-term and qualitative preservation of data in a consistent manner in line with the FAIR and CARE principles and in compliance with the policy and/or legal frameworks [24–28]. In brief, data curators should have profound knowledge and technical skills to ensure that data are being stored and archived in such a manner that allows for long-term usage in terms of readability, re-usability and exchange of the data, for instance with third parties.

Next, digital libraries should also include the role of (EOSC) educator, i.e. the person who has a profound understanding of the research data ecosystem (ex. EOSC), its mode of operation and the related principles and frameworks [24–28]. In

particular the (EOSC) educator should have educational and communication skills in order to transfer this knowledge to researchers across disciplines, for example through the development of adequate training material for different target audiences.

As state above, the 3 roles described here in detail do not exclude digital libraries to consider other roles that might be needed according to their specific organisational setting. In fact, qualitative research data management cannot be reached in isolation, but merely requires the embedding of all roles recognised by the EOSC Executive Board Skills & Training Working Group within an organisational setting. However, the three roles described above provide digital libraries with a means to prioritise the development of the required digital skill sets for FAIR and Open Data. Although there are currently no focused training programs for these profiles in Flanders, shifts are taking place that will make training possible on the short to medium term, mainly due to the obligations imposed by the Flemish Open Science Policy as well as the advent of the EOSC Association. In the meanwhile, online courses and training initiatives such as those offered by DCC and others might serve as an interim solution [29].

4. Conclusion

Since the advent of the digital age, traditional libraries have been transforming to digital libraries. Digitisation has reshaped the structure, format and processes that libraries use to ensure the preservation, curation, publication and dissemination of digital content. While in the early days, digitisation processes mostly took place on (research) publications, the past decades a shift has taken place to all kinds of digital scientific materials, including research data. This shift has been accelerated with the Open Science movement, and Open Data in particular, which aims to make scientific findings freely available to everyone to be used and republished, without any restrictions. Furthermore, the current investment of Europe in the establishment of EOSC has more than ever stressed the importance of managing research data in order to enhance the flow of research data and scientific knowledge between researchers, institutions and disciplines. The importance of FAIR and Open Data in fact acts a lever to further develop the role of academic libraries as hubs of digital information. In order to take on this role, digital libraries must ensure that the infrastructure is in place to store research data, in collaboration with the ICT department and the research community, and that librarians have the required digital skill set for handling FAIR and Open Data.

In order for academic libraries to manage infrastructures for research (meta) data, it is prerequisite to incorporate software and a metadata model for research data that is in line with the research institution's goals and processes and that allows the interoperable exchange with other digital resources worldwide. Over the past decade, many research communities have been developing metadata models for research data and crosswalks between different models are missing. This prompted the Flemish Government, to contract ECOOM-Hasselt to coordinate the creation of a Flemish application profile for research metadata that will be used by all Flemish research institutions. The resulting application profile is based on the DataCite metadata standard 4.3, yet comprises some minor customisations in terms of properties and semantics, according to the Flemish context and use purposes. The proper implementation of the metadata model in the institutional repositories, can however only be ensured when business and validation rules are developed and implemented that guarantee its correct use. Moreover, it also allows for the uniform delivery of metadata on research data to the FRIS-portal by all Flemish information providers, i.e. the universities, higher education colleges, strategic research centers and research institutions.

Next to the development of digital libraries as infrastructures for research (meta)data in collaboration with ICT and the research community, one obviously also needs to have the required competences in terms of human resources on board. In this respect, digital libraries should focus on the investment in digital skill sets for, in particular data librarians/data stewards, data curators and (EOSC) educators. In brief, these digital skill sets aim to preserve, store and curate research data, according to policy and/or regulator obligations, and enable future use of high quality (disciplinary) research data, in an easily accessible and consistent manner, including the transfer of the knowledge thereof to the research community. Altogether, FAIR and Open research (meta)data can truly act as a leverage for digital libraries and their future perspectives.

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Abbreviations

CARE	Collective benefit Authority to control Responsibility Ethics
CRIS	Current Research Information System
DOI	Digital Object Identifier
CERIF	Common European Research Information Format
EOSC	European Open Science Cloud
EWI	Department Economy, Sciences and Innovation of the Flemish Government
FAIR	Findable, Accessible, Interoperable, Reusable
FOSB	Flemish Open Science Board
FRIS	Flemish Research Information Space
OECD	Organisation for Economic Co-operation and Development
SRIA	Strategic Research and Innovation Agenda
VLIR	Flemish Interuniversity Council

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