Fachbeitrag

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Developing a Pan-European Open Science Training Landscape

The Project Skills4EOSC and Selected Initiatives

Entwicklung einer europaweiten Open-Science-Trainingslandschaft

Das Projekt Skills4EOSC und ausgewählte Initiativen

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Abstract: In an environment designed to increasingly enable Open Science, not all researchers and research supporting units have the required competences. Moreover, there is a lack of clear data professionals' profiles and corresponding career paths, and a high degree of fragmentation in training resources. This article presents the Horizon Europe project "Skills4EOSC" and other selected initiatives that contribute to the goals of the European Open Science Cloud, and in particular to the creation of a harmonised training landscape. The transition to Open Science implies that researchers and research-supporting experts acquire new skills, which also requires new and additional forms of training. Together, and step by step, efforts add up to a common and trusted pan-European ecosystem.

Keywords: Open Science, European Open Science Cloud (EOSC), Data Stewards

Zusammenfassung: In einem Umfeld, das vermehrt Open Science ermöglichen soll, verfügen dennoch nicht alle Forschenden und forschungsunterstützenden Einrichtungen über die erforderlichen Kompetenzen. Es fehlt an klaren Profilen von Daten-Professionisten und entsprechenden Karrierewegen. Zudem gibt es eine Fragmentierung der Ausbildungsressourcen. In diesem Artikel werden das Horizon Europe Projekt "Skills4EOSC" sowie andere ausgewählte Initiativen vorgestellt, die zu den Zielen der European Open Science Cloud und insbesondere zur Schaffung einer harmonisierten Ausbildungslandschaft beitragen. Der Übergang zu Open Science erfordert, dass Forschende und forschungsunterstützende Expertinnen und Experten neue Fähigkeiten erwerben, die auch neue und zusätzliche Formen der Ausbildung implizieren. Gemeinsam und Schritt für Schritt wird an einem gemeinsamen und vertrauenswürdigen europaweiten Ökosystem gearbeitet.

Schlüsselworte: Offene Wissenschaft, European Open Science Cloud (EOSC), Data Stewards

1 Introduction

The research ecosystem is going through a period of profound change. Researchers, academic teachers, research supporting units, research performing organizations, research funding bodies, and the interacting citizen scientists, to name just a few of the involved stakeholders, are reshaping the research process and its outputs, based on the digital transition and constantly evolving technologies. This change implies that researchers and research supporting professionals acquire new skills. Since 2016, the European Commission has organised its Open Science policy according to 8 "pillars", with one of them "Education and Skills", and mentions that "all scientists in Europe should have the necessary skills and support to apply open science research routines and practices." In 2017, the Expert Group on Education and Skills under Open Science of the European Commission published a report about skills and competencies researchers need, in order to practise Open Science.[1] The report concluded that the skills should be aligned in the

1 European Commission, Directorate-General for Research and Innovation, C. O'Carroll, B.,Hyllseth, R. Berg, et al. "Providing researchers with the skills and competencies they need to practise Open Science." *Publications Office*, 2017. https://data.europa.eu/doi/10.2777/121253.

following categories: Open Access to publications, management of research data, and citizen science.

Moreover, the current situation still lacks a clear definition of data professional profiles and corresponding career paths, and it reveals a fragmentation in training resources. This article presents the EU project Skills4EOSC,[2] as well as other initiatives, which aim to unify the current training landscape, to fill gaps and/or which reach out to new target groups. In this endeavour, they contribute to the building process of the European Open Science Cloud (EOSC),[3] aiming to develop networks, methodologies and materials in a coordinated way across Europe.

2 Contextualising Open Science

The opening of science started many decades ago, with pioneer activities such as the preprint repository arXiv in 1991. Then some major Open Access initiatives took place, as the three international declarations, known as the BBB: in 2002 the Budapest Open Access Initiative (BOAI)[4] and in 2003 the Bethesda Statement on OA Publishing[5] and the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities.[6] Those declarations led to the definition of Open Access, highlighting not only the access to the knowledge, but also the importance that authors should retain the rights and control of their work, and to be properly acknowledged.

Over the years, the need to open scientific knowledge was extended. Not only should publications and other research outputs (i. e., data) be open, but also the different processes until the results are achieved. This is how after 2012, several declarations for Open Science were signed, starting with the Open Science for the twenty-first century, a declaration of all European Academies in 2012[7] and leading to the Vienna Declaration on the European Open Science Cloud in 2018,[8] where free access to research data under the FAIR principles is a key aspect in the opening of science. In 2021, Open Science was defined by the UNESCO as

> an inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community.[9]

It is widely accepted that "Open Science" stands for the transition to a new, more open and participatory way of conducting, publishing and evaluating scholarly research. Central to this concept is the goal of increasing cooperation and transparency in all research stages. This is achieved, among other ways, by sharing research data, tools and results (not exclusively in form of publications) as early and as open as possible. Furthermore, data should be made available as decentralized as possible, and as centralized as necessary. This will enable faster access to science and to scientific results for everyone, resulting in a greater societal and economic impact.[10] Following this concept, Open Science is not the target, but the tool to have sounder science, more responsive to societal needs. In particular, the adoption of the FAIR principles should be highlighted. The findability, accessibility, interoperability, and reusability (FAIRness) of research publications, underlying data, and software in the digital space will define research and innovation going forward.

It is thus important to make researchers and policymakers aware that Open Science is not just a trend, but necessary to make science reproducible and transparent. Ultimately, it is about performing good and more responsible research, following the Responsible Research and Innovation principles, which ensure that research has a real impact in the society. Currently, a big challenge is the alignment of the evaluation systems to these new developments. Related to that, a new Agreement on Reforming Research Assessment[11] was published in July 2022, in order to reward researchers according to new and innovative activities. Re-

2 "Skills4EOSC," accessed January 24, 2023, https://www.skills4eosc.eu/.
3 "European Open Science Cloud (EOSC)," accessed January 24, 2023, https://eosc.eu/.
4 "Budapest Open Access Initiative," accessed January 23, 2023, https://www.budapestopenaccessinitiative.org/read/.
5 "Bethesda Statement on Open Access Publishing," accessed January 23, 2023, http://legacy.earlham.edu/~peters/fos/bethesda.htm.
6 "Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities," accessed January 23, 2023, https://openaccess.mpg.de/Berlin-Declaration.
7 "Open Science for the 21st century. A declaration of ALL European Academies," accessed January 23, 2023. https://www.allea.org/wp-content/uploads/2015/09/OpenScience-Rome-Declaration-final_web.pdf.
8 "The Vienna Declaration on the European Open Science Cloud," accessed January 23, 2023, https://eosc-launch.eu/declaration/.
9 UNESCO, "UNESCO Recommendation on Open Science," accessed January 24, 2023, https://unesdoc.unesco.org/ark:/48223/pf0000379949.locale=en.
10 Concerning the different definitions of Open Science, we would like to refer to: https://doi.org/10.32388/838962 and https://www.qeios.com/read/838962, accessed January 23, 2023.
11 "Agreement on Reforming Research Assessment," accessed January 24, 2023, https://coara.eu/agreement/the-agreement-full-text/.

searchers should be prepared for new criteria, considering a variety of research outputs beyond the publication of research articles, as well as new research environments, including the use of AI modules, among others.

In order to implement openness with the necessary quality and to exploit optimally the potential of technologies, new and additional forms of trainings are required. Researchers should be appropriately skilled in the use of digital and AI methods for data collection and processing and use them critically and reflectively.[12] Machine-based methods and AI will increasingly shape the future of research and innovation. As the Leiden Declaration on FAIR Digital Objects[13] points out, the adoption of legal frames and guiding policies as well as monitoring are needed. Trust in data and the associated services are essential if we want to avoid the internet being flooded with qualitatively inadequate information in the future and dominated by algorithms without clear and traceable origins and processes.

The European Commission has contributed to raise the awareness of Open Science with several initiatives, like the FOSTER project[14] or the OpenAIRE[15] network, among many others. Additionally, numerous infrastructures have been developed to make Open Science possible. In the following section, a multi-disciplinary environment will be described closer, in which researchers are supposed to publish, find and re-use data, tools and services, enabling them to better conduct their work.

3 The European Open Science Cloud (EOSC)

The EOSC is an important initiative in Europe to advance the federation of research infrastructures in Europe for FAIR access to data, and to create a web of FAIR data and related services for research, innovation and educational purposes.[16] The environment will operate under well-defined conditions to ensure trust and safeguard the public interest.

The European Commission supports the development of EOSC on behalf of the European Union.[17] The EOSC is one initiative among the 20 actions of the policy agenda 2022–2024 of the European Research Area (ERA) with the specific objective to deepen Open Science practices in Europe.[18] At the World Economic Forum in January 2020 in Davos, Commission President Ursula von der Leyen described EOSC as a "trusted space for researchers to store their data and access data from other disciplines".[19]

12 In the course of the H2020 project "EOSC Secretariat", WP3 Stakeholder Engagement, Sub Task Researchers Engagement, surveys were carried out, involving actors from different research fields, among them ERC, Marie Curie Alumni Association, Young Academy of Europe. See Report on the Workshop 'Co-creating the EOSC: Needs and requirements for future research environments', https://www.doi.org/10.5281/zenodo.3701194, Feldkirch/Vienna 9 March 2020. The conclusions were many, and we would like to recall one of them, which relates very well to the issues presented in this article, and especially to the realisation of the postulates concerning Open Science and the adoption of FAIR principles on all research processes: "Researchers might be 'replaced' by machines and AI, as they are out-performing human beings on a number of until recently unimaginable tasks, with further improvements to be expected".

13 "Leiden Declaration on FAIR Digital Objects," accessed January 24, 2023, https://www.fdo2022.org/site/fdo/programme/leiden-declaration.

14 "Foster," accessed January 24, 2023, https://www.fosteropenscience.eu/.

15 "OpenAIRE," accessed January 24, 2023, https://www.openaire.eu/.

16 Following the launch of the EOSC, an article defining the EOSC was published in ABI Technik. It was the most downloaded article on the ABITECH website in 2019: Budroni, Paolo, Jean-Claude Burgelman, and Michel Schouppe. "Architectures of Knowledge: The European Open Science Cloud." *ABI Technik* 39,2 (2019): 130–141. https://beopen-project.eu/storage/files/abi-technik-architectures-of-knowledge-the-european-open-science-cloud.pdf, accessed January 24, 2023.

17 The EOSC is NOT a cloud made in Brussels: What started, at the European level, with a Council conclusion on open, data-intensive and networked research as a driver for faster and wider information in 2015 (http://data.consilium.europa.eu/doc/document/ST-9360-2015-INIT/en/pdf, accessed January 23, 2023), was followed by a Council conclusion on the transition towards an open science system in 2016 (https://data.consilium.europa.eu/doc/document/ST-9526-2016-INIT/en/pdf, accessed January 24, 2023), then supported by the European Parliament by a resolution on the European Cloud initiative, converged into a Council conclusion on EOSC in 2018 (http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_ATA(2017)599253, accessed January 24, 2023), and finally resulted in the official launch of the EOSC and its governance structure by the acclamation of the Vienna Declaration in November 2018 "Vienna Declaration on the EOSC" (https://eosc-launch.eu/declaration, accessed January 24, 2023).

18 The EOSC is also recognised by the European Commission "as the 'science, research and innovation data space' which will be fully articulated with the other sectoral data spaces defined in the European strategy for data," accessed January 24, 2023, https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science/european-open-science-cloud-eosc_en.

19 EC President Ursula von der Leyen talks EOSC in Davos: "We are creating a European Open Science Cloud now. It is a trusted space for researchers to store their data and to access data from researchers from all other disciplines. We will create a pool of interlinked information, a 'web of research data'. Every researcher will be able to better use not only their own data, but also those of others. They will thus come to new insights, new findings and new solutions." Accessed Jan-

The governance of EOSC takes the form of a tripartite collaboration between the European Commission on behalf of the European Union, participating countries represented in the EOSC Steering Board and the research community represented by the EOSC Association AISBL (EOSC-A). The Commission and EOSC-A signed a memorandum of understanding for a co-programmed European partnership[20] in July 2021. Several European Commission services are directly involved in the work of the current EOSC governance. They provide input and advice for the development of key documents, such as the Strategic Implementation Plan (SIP),[21] the Partnership Proposal and the SRIA (Strategic Research and Innovation Agenda).[22] In the spirit of tripartite collaboration, all stakeholders can provide input to key documents and influence the further development of EOSC.

A broader reflection on EOSC operations and evolution post-2027 is currently underway also in the EOSC building Horizon Europe project EOSC Focus, which is coordinated by the EOSC Association. Tripartite stakeholders are invited to reflect what EOSC should be in five years from now, specifically regarding its governance, funding sources and tools, and the tripartite partnership itself. These joint activities enable a joined-up thinking on the uptake of Open Science practices in Europe and to align relevant national and EU policies and investments to improve the production of FAIR research output that are "as open as possible, as closed as necessary".

The SRIA establishes three strategic objectives for EOSC:

- ensure that Open Science practices and skills are rewarded and taught, becoming the "new normal",
- enable the definition of standards, and the development of tools and services,
- allow researchers to find, access, reuse and combine results; establish a sustainable and federated infrastructure enabling open sharing of scientific results.

Ultimately, the aim is to enable researchers to find, access and (re-)use interoperable research data stored on any data infrastructure that is linked to EOSC and, in turn, help them collaborate more easily across national and disciplinary borders. Setting this up will require a holistic approach: EOSC will support the storage, curation and re-use of data through technical and policy standards and training. Research performing organisations are key actors in EOSC as they are producers, users and re-users of research data. They provide research infrastructures, including data infrastructures, and enable the production of research data, as well as define policies for research data management.

4 EOSC and Data Spaces

Besides the upcoming realisation of the EOSC, the pan-European landscape is also undergoing a transformation due to the emerging, so-called "Common European data space". A data space can be defined as a federated data ecosystem based on shared policies and rules. Such a data space enables users to access data in a secure, transparent, trusted, easy and unified fashion.

According to the proposed governance models, data holders should remain in control of who can have access to their data, for which purpose and under which conditions it can be used. The realisation of this kind of data spaces will additionally boost the introduction of Open Science at all societal levels, also including the European research infrastructures. In this context, the EC plays a key role in supporting the creation of this kind of data spaces.[23] Two of the expected impacts of this development should be mentioned because they will create a huge resonance in Open Science. The first will be the increased trust in data sharing (neutral data intermediaries), the second is to unlock the potential of the EU's industrial data and ensure fairness in the allocation of data value among the actors of the data economy, including the research activities.

uary 24, 2023, https://eosc-portal.eu/news/ec-president-ursula-von-der-leyen-talks-eosc-davos.

20 "Memorandum of understanding for a co-programmed European partnership," accessed January 24, 2023, https://www.eosc.eu/sites/default/files/EOSC_Memorandum_30_July_2021.pdf.

21 European Commission, Directorate-General for Research and Innovation, S. Jones, and J. Abramatic. "European Open Science Cloud (EOSC) strategic implementation plan." *Publications Office*, 2019. https://data.europa.eu/doi/10.2777/202370.

22 European Commission, Directorate-General for Research and Innovation. "Strategic Research and Innovation Agenda (SRIA) of the European Open Science Cloud (EOSC)." *Publications Office of the European Union*, 2022. https://data.europa.eu/doi/10.2777/935288.

23 Referring to the Common European data spaces, compare: "Staff working document on data spaces", accessed January 24, 2023, https://digital-strategy.ec.europa.eu/en/library/staff-working-document-data-spaces; compare also: Milani, Federico. "Deployment of common European data spaces." Presented at e-IRG Workshop under Czech EU-Presidency in Prague, 13th December 2022, and available at: https://events.geant.org/event/1323/contributions/1311/, accessed January 24, 2023; a full size image of the foreseen common European Data spaces is available at this link: https://link.springer.com/chapter/10.1007/978-3-030-98636-0_16/figures/1, accessed January 24, 2023.

5 The Horizon Europe Project Skills4EOSC

In the Open Science context mentioned above, 44 European Open Science "key doers" in their regions and domains (including 2 ESFRI[24] Research Infrastructures), from 18 countries (Austria, Belgium, Bulgaria, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Netherlands, North Macedonia, Norway, Poland, Serbia, Spain, Sweden, United Kingdom) gathered together into a consortium. Skills4EOSC is a Coordination and Support Action funded by the European Union under the HORIZON-INFRA-2021-EOSC-01 ("Supporting an EOSC-ready digitally skilled workforce").

5.1 Skills4EOSC Setup

This ambitious project addresses challenges set out in the SRIA. Skills4EOSC will create an EOSC-ready skilled European workforce, connecting existing centres of competence in Open Science and scientific data management. The aim is to develop methodologies, activities and training resources to unify the current training landscape into a collaborative and reliable ecosystem and to provide dedicated community-specific support to leverage the potential of EOSC for open and data-intensive research. Skills4EOSC will engage different academic and expert groups, numerous researchers, professionals and governmental entities to test and complete the proposed training methodology and assets.

The main objective is thus to advance Open Science skills by unifying the current training landscape into a common and trusted pan-European ecosystem, closing the three gaps identified in the SRIA:

- lack of Open Science and data expertise,
- lack of a clear definition of data professional profiles and corresponding career paths, and
- fragmentation in training resources.

In order to achieve this objective, Skills4EOSC aims at a) offering a FAIR-by-design methodology for Open Science teaching and learning; b) proposing to raise general competences for an EOSC-skilled European workforce; c) coordinating the creation of a network of Competence Centres on Open Science and FAIR Data.

A special meaning is therefore assigned to the concept of the Competence Centres. Until now, no well-established definition of Competence Centre is found in literature. The European Network of Innovation Agencies states that Competence Centres can be defined as structured, long-term research and innovation (R&I) collaborations in strategically important areas between academia and industry/the public sector. They focus on strategic research agendas, support strong interactions between science and industry and provide truly collaborative research with a medium to long-term perspective.

In Skills4EOSC, Competence Centres are seen as centres of gravity of Open Science and EOSC activities in their countries. These entities can be established either as national initiatives or as organisations that have the leading or mandated contribution to the Open Science activities nationally (such as e. g., national cloud provider, national research and education network, or core universities). The envisaged Competence Centres pool the expertise available within research institutions, universities and thematic and cross-discipline research infrastructures. According to the vision of the project, the centres should act as entities that federate existing institutions and or research centres. They should be structured as a network that coordinates its activities in a cluster of entities, which act without losing their autonomy or giving up any rights to their knowledge.

5.2 Expected Impact and Benefits of Skills4EOSC

Skills4EOSC follows a multilevel approach, enabled also by the high-level competence of the consortium. As already pointed out, Open Science may affect a broad spectrum of social developments. Therefore, the addressees of the project are diverse, and so is the wide range of expected benefits:

Acceleration of FAIR-enabling processes: through the goal of unifying the current training landscape into a common and trusted pan-European ecosystem, Skills4EOSC expects more efficient upskilling of European researchers and data professionals in the fields of FAIR and Open Data, thus promoting intensive data science and scientific data management as an integral part of research processes.

Pooling of expertise: the introduction of Competence Centres is expected to pool the expertise available within research institutions, universities, as well as thematic and cross-discipline research infrastructures.

Production of qualified materials, codified curricula and improvement of outreach: the offered training and support, as well as empowerment and lifelong learning will bring resources to a variety of stakeholders, including not only researchers, data stewards and infrastructure opera-

24 European Strategy Forum on Research Infrastructures (ESFRI), accessed January 24, 2023, https://www.esfri.eu/.

tors, but also funders, decision-makers, civil servants and people working in business and industry.

Maximised conscientisation of Open Science processes at domestic level: having close access to policymakers and thanks to their position at the heart of the above-described multi-stakeholder landscape, the Competence Centres represented by the Skills4EOSC partners are expected to play a pivotal role in national plans for Open Science and in the interaction with scientific communities.

Greater involvement of researchers in the EOSC building process and empowerment of stakeholders: through the activities of the Skills4EOSC project, researchers can make better decisions about how to participate in the Open Science movement and may transform how they carry out research and exploit research outputs, leading to better quality and contributing to the Horizon Europe EOSC Partnership.

The European Commission adopted the proposal to make 2023 the European Year of Skills,[25] following the announcement made by President Ursula von der Leyen in her 2022 State of the Union address in September 2022 in Strasbourg.[26] President Ursula von der Leyen reinforced that "We need an enabling business environment, a workforce with the right skills", reinforcing the timeliness of Skills4EOSC.

5.3 Curriculum Development in Skills4EOSC

The Skills4EOSC project dedicates one full work package to building curricula and learning paths for Open Science ready institutions. It wants to drive the co-creation of harmonised trainer accreditation pathways, academic and professional curricula and skills quality assurance, recognition frameworks and methodologies for the creation of learning material. Target groups are undergraduate students and PhD students, data stewards and professionals, data librarians and curators, as well as legal and ethical experts.

Universidad Carlos III de Madrid leads the work package; task-leading institutions are TU Delft, Tampere University in Finland, the Royal Danish Library and KU Leuven. Many other institutions contribute to the tasks. Different objectives are pursued, depending also on the different target groups. In order to address the need for Open Science professionals, one goal is to design harmonised curricula and learning paths for data stewards ("European Curriculum for data stewards"), to ensure alignment, uniformity, quality and recognition of the acquired competences across Europe and beyond. For the target group of students, it will be necessary to define "Open Science essentials" to include undergraduate and PhD courses, as well as competences for support professionals. Below, the individual tasks will be presented in more detail.

The task "Training curriculum for data stewards" will develop a training curriculum for data stewards. The curriculum will build, among other resources, on the RDNL "Essentials for Data Support"[27] training for data professionals. Community consultation will be sought during the curriculum development, for example through the "RDA Professionalising Data Stewardship Interest Group"[28], and through other existing data stewards' networks to align with community needs and support adoption. Curriculum adoption at a national level will be supported through the national Competence Centres of the Skills4EOSC network by providing train-the-trainer sessions and dedicated pilots.

The task "Learning paths for data professionals" will design and pilot learning paths for data professionals including data stewards, data librarians, data curators and research support staff, as well as other professional roles. In addition to train-the-trainer sessions and pilots, professional networks and the fellowship programme will play a key role in supporting lifelong learning for data professionals.

The Task "Open Science essentials at undergraduate level" will reshape existing undergraduate courses on information and data skills to increase the availability of highly and appropriately skilled professionals enabling Open Science in all fields, and any academic career development. This task will design a set of courses on essential Open Science skills and data stewardship. Specific requirements for the STEM and SSH sectors will be identified to support professionals in these fields to pursue data stewardship careers and related career paths in academia or industry. The independent course will be available to be incorporated into curricula at bachelor and master's levels. Tailored train-the-trainer sessions will be delivered to the Competence Centres experts and pilots will be run in Skills4EOSC partner universities. Addressing undergradu-

25 "Commission kick-starts work on the European Year of Skills," accessed January 24, 2023, https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6086.

26 "2022 State of the Union Address by President von der Leyen," accessed January 24, 2023, https://ec.europa.eu/commission/presscorner/detail/en/speech_22_5493.

27 "Essentials 4 Data Support," accessed January 24, 2023, https://datasupport.researchdata.nl/.

28 "Professionalising Data Stewardship IG," accessed January 24, 2023, https://www.rd-alliance.org/groups/professionalising-data-stewardship-ig.

ates also means adapting to the programme and career assessment at a national level.

In the task "Open Science ready PhD curricula", Open Science elements for PhD curricula will be studied, aligned and designed. Modules will be delivered that can be embedded in PhD curricula taking into consideration the disciplinary needs of the STEM and SSH sectors, and the different years of PhD studies which reflect different levels of expertise and comprehension in relation to research activities, data management and Open Science. In line with the Skills4EOSC methodology, pilots to test the effectiveness and gather feedback from universities of the consortium will follow train-the-trainer sessions at Competence Centres.

The task "Integrating ELSI[29] in curricula and learning paths for OS ready institutions" will integrate key legal, ethical and social aspects in the design of curricula and learning paths for data stewards, data professionals, PhD and undergraduate students. IPR, PSI, open data, data protection, licensing, as well as a responsible and participatory approach to research and integrity are some key elements that will be addressed. Appropriate learning materials and elements of the curricula and learning paths will be designed to comprehensively address the ELSI framework.

Until 2025, the following Deliverables are to be expected:

- European Curriculum for data stewards (until April 2025)
- Learning paths for data professionals (until June 2025)
- Open Science essentials for undergraduate programmes and doctoral schools (until August 2025)
- Selected related training initiatives in Europe

With relation to data stewards' trainings, complementary concepts are evolving: designing full professional data stewardship curricula to establish data stewardship as a core qualification and profession, as well as providing focused training courses to the data producers and data processors themselves, i. e., the researchers. There are several reasons for reaching out to the researcher target group as early as possible, so there are some approaches to include data stewardship and Open Science essentials into undergraduate and PhD courses. Hereby, we would like to present some examples of ongoing trainings and training concepts in the planning.

In Austria, the University of Vienna launched the Certificate Course "Data Steward"[30] in autumn 2022. In order to build skills and competences for the EOSC as well as research institutions in Austria, the Vienna University Library developed a fee required, part-time further education program in English: the certificate course "Data Steward". The contents are based on the previously offered certificate course "Data Librarian", the results of the FAIR Data Austria project[31] and similar programs such as "DataTrain"[32] and "Zertifikatskurs FDM"[33] in Germany. The course supports both existing staff and new hires in generic and domain-specific data stewardship roles in acquiring knowledge and key competences to perform the tasks of data stewards at research institutions. The course was designed following three guiding principles: competence acquisition, peer-to-peer learning and community building. The academic degree will be "Certificate of the University of Vienna", with a duration of two semesters and credits amounting to 15 ECTS in total. Due to a lack of codified courses like this one, the interest was very high. There were far more registrations than places offered, from all over Europe and beyond. The first round started with 25 emerging data stewards from ten countries in October 2022. The next round will be in October 2023.

While many research institutions implement so-called data stewards, the TU Wien is working on an additional and complementary approach. It aims at bringing data stewardship and Open Science topics to the future data producers and data processors themselves, namely to the students in various research disciplines. TU Wien is in the process of introducing a supplementary master's programme "Data Management" that will address students of all disciplines offered by the university, promoting transversal skills in data management. It should be offered by the Faculty of Informatics to students of all other faculties and consist of existing courses and a few new courses to be developed. The goal is to raise awareness of IT and legal knowledge early on and to make them an integral part of the project as well as research activities. This should prepare students for current and upcoming demands in academia and industry and help them to ensure competitiveness on an international level. This supplementary master's programme will be elaborated and offered within a period of the next three years. In the meanwhile, and within a supplementary frame, Open Science is also covered in the course on Publishing and Dissemination of Scientific work for Master and

29 ELSI: ethical, legal and social implications.

30 "Data Steward," accessed January 24, 2023, https://www.postgraduatecenter.at/en/programs/communication-media/data-steward/.

31 "FAIR Data Austria," accessed January 24, 2023, https://forschungsdaten.at/fda/.

32 "Data Train," accessed January 24, 2023, https://www.bremen-research.de/data-train/.

33 "Zertifikatskurs Forschungsdatenmanagement," accessed January 24, 2023, https://www.th-koeln.de/weiterbildung/zertifikatskurs-forschungsdatenmanagement_82048.php.

PhD students, offered by the TU Wien Library, as part of the so-called Transferable Skills program.

Acting similarly, but in an effort to offer a full master curriculum, the National College of Ireland (NCI) is in the process of designing a "Master of Science in Open Data Management" – equivalent to 90 ECTS in the NCI – as well as a "Post-graduate Diploma in Open Data Management" – equivalent to 60 ECTS. The overall goal is to provide graduates with essential research and development skills in the field of Open Data Management. Graduates should gain competence to understand the impacts, design, application and operationalisation of Open Data Management solutions as well as put them in a position to make informed and critical decisions regarding requirements elicitation and analysis, implementation and evaluation in the field of Open Data Management. Learners on the programme will gain in-depth knowledge topics of programming, Open Science, ethics, data analytics, data governance, data modelling, statistics and research aspects. The programme is currently being submitted for revalidation with the internal review panel.

Another important target group that requires structured training is the people who operate infrastructures and services. The currently running European H2020 project "RItrainPlus"[34] aims at delivering trainings to research infrastructures and core facilities. The project furthermore focuses on business management schools and European universities, the overarching goal being to design and deliver a training programme to fulfil the competency requirements for the current and future managers of European research infrastructures and core facilities. Research infrastructures and advanced scientific facilities are complex organisations. These groups work with a large number of different stakeholders and funding mechanisms. Managers of research infrastructures should have a scientific understanding, be part of or at least close to the scientific user community "and at the same time balance the scientific needs and the technical possibilities with the management skills necessary for the operation of large, expensive facilities and the diplomatic skills required to engage with and define agreements between a large number of international actors".[35] Indeed, it is clear from many policy documents that there is recognition that well-trained, highly skilled personnel are needed for the long-term operation of research infrastructures and services. In this respect, consortia like in RItrainPlus are a very good start.

An interesting initiative for Early Career Researchers is the program "UC3M Ticket to Open Science" at the Universidad Carlos III in Madrid (Spain). This Open Science training is organised by the Vice Rectorate for Research Policy for their PhD students, as part of the Human Resources Strategy for Researchers (HRS4R)[36] actions. The course corresponds to two ECTS, takes place over six weeks and is divided into 1.5 lectures + one hour of an Open Science Café.[37] The sessions cover subjects like a general explanation of what is Open Science, Open Access to publications and data, planning open responsible research, or how to disseminate research, among others.

A further noticeable project on doctoral education in the field of Open Science is the DIOSI project, finished in December 2022.[38] The purpose of the DIOSI Model was the development and implementation of hands-on training on Open Science and Open Innovation for Early Career Researchers. Additionally, the project presents a proposal for measuring the impact of such training through a graduate tracking framework, at individual, institutional and societal level. At individual level, a follow-up is planned at six months and two years after graduation. The long-term perspective considers the impact of the university and the society by the definition of specific indicators.[39] The project provided not only training for doctoral and early career researchers, but also train-the-trainer sessions.

Another interesting initiative takes place in Italy, at the University of Brescia. The Inter-University Master's Degree Course in Artificial Intelligence, Mind, Enterprise (IAMI) implements the "European Coordinated Plan on AI" (2018) and the Italian "National Strategy for the Development of AI" (2020). The IAMI proposes, first in Italy, a high-level training course on AI and its relationship with Mind and Enterprise. It is aimed at managers, professionals and researchers, offering the transversal skills and knowledge required to manage the new technology, starting from the assumption

34 "RItrainPlus," accessed January 24, 2023, https://ritrainplus.eu/.

35 "RItrainPlus," accessed January 24, 2023, https://ritrainplus.eu/ritrainplus-project/.

36 The HRS4R award gives public recognition to research institutions that implement the principles set out in the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers (C&C), as published on the EURAXESS portal: https://euraxess.ec.europa.eu/jobs/charter in their policies and practices, accessed January 24, 2023. For further information: EURAXESS portal https://euraxess.ec.europa.eu/jobs/hrs4r, accessed January 24, 2023.

37 "UC3M TICKET TO OPEN SCIENCE, Special Training for PhD Students," accessed January 24, 2023, https://www.curatore.es/uc3m2OpenScience/about/.

38 "DIOSI project,", accessed January 24, 2023, https://diosi.eu/.

39 Golob, Boris, Annemarie Künn-Nelen, Zoran Sušanj, Nikoleta Zubić, and Saša Zelenika. "DIOSI Impact and graduate tracking Framework: self-report questionnaire adapted to the course contents and methodology to assess long-term impact." *Zenodo* (2022). https://doi.org/10.5281/zenodo.7351179.

that AI synthesizes different disciplines: engineering, logic, philosophy, neuroscience, law, data science. The training course is built on the interconnection of disciplines-based languages and has two aims: (1) to give a "holistic" vision, and (2) to bring the world of work into the lessons of the Master, hosting testimonies from managers and entrepreneurs, as well as to bring the Master into the world of work with internships and visits.[40]

Finally and importantly, the GO FAIR[41] initiative should be mentioned, as a player that acts globally and thus reaches out of Europe. GO FAIR is in the process of establishing a train-the-trainer network, with in-depth knowledge of the FAIR principles and methods of teaching them to interested and relevant target groups. The training materials should be shared and openly available, for example via a platform such as FAIR Connect.[42]

6 Conclusion

The need to offer Open Science skills in a structured way is emerging across many European institutions. Furthermore, there is a desire for clear data steward and other data professional job profiles along with a codified training for these groups. In some areas, especially in the data steward formation, beginnings have been made, and courses are running in first iterations. With regard to the target group of students, some interesting curriculum developments take place. Addressing undergraduates, as an additional complicating factor, means adapting to the programme and career assessment at a national level. Another important target group that requires structured training is the infrastructures and services operators. Research infrastructures and advanced scientific facilities are complex organizations. They work with a large number of different stakeholders and funding mechanisms. Managers of research infrastructures should have a scientific understanding, be part of or at least close to the scientific user community and be able to make assessments about the technical possibilities.

The need of a good understanding of concepts related to Open Science, and particularly in research data management, are important at several levels, and training activities need to go beyond researchers' activities. The development of any policy should be accompanied by infrastructures, incentives, user experiences and training. Currently, various training concepts are evolving, particularly (1) designing full data stewardship curricula to establish data stewardship as a core qualification and profession across a broad range of domains, and (2) developing focused training courses to experts in a specific domain. While both are needed, the latter seems to be an urgent addition. Only domain experts have a sufficient in-depth understanding of their data and know best how to design and select the best solution for data management by taking into consideration existing good practices already in place within the given community. Additionally, it is easier for researchers to understand and accept the value of having expert support if colleagues from the same domain provide it. Ultimately, having highly qualified data stewardship specialists with some domain knowledge, as well as domain experts with some data stewardship expertise, will allow us to establish the necessary levels of communication and mutual understanding required to tackle the technical, legal and organisational challenges emerging from an increasingly data-driven environment in academia, business and industry.

In the Skills4EOSC project, as well as in the other selected initiatives presented in this article, both approaches are being followed. They drive the creation of coordinated trainer accreditation pathways, academic and professional curricula and skills quality assurance, recognition frameworks and methodologies for the creation of learning material. Training concepts need to be compliant with funding and publishing requirements, the content of the curricula being developed need to include non-research competencies, such as communication, business development, teaching, etc. Much work has been done already, and using previous experiences is key to make a harmonisation possible.

After all, Open Science stands for the transition to a new, more open and participatory way of conducting, publishing and evaluating scholarly research. Central to this concept is the goal of increasing cooperation and transparency in all research stages, accompanied by trainings and enabling technologies. Many existing frameworks have to be taken into account, and the developments will take time to get mature. Step by step however, all the efforts are slowly adding up to a round picture.

40 The promoter of IAMI is the University of Brescia in cooperation with the CIMeC of the University of Trento, TU Wien, the Casa Severino Centre in Brescia and the H. Hospital. Valduce Villa Beretta in Lecco.

41 "GO FAIR," accessed January 24, 2023, https://www.go-fair.org/.

42 "FAIR Connect," accessed January 24, 2023, https://fairconnect.pro/.

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