YUFERING Project

YUFE TRANSFORMING R&I THROUGH EUROPE-WIDE KNOWLEDGE TRANSFER

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List of Acronyms and Abbreviations

CARE	Collective benefits, Authority to control, Responsibility, Ethics
CESSDA	Consortium of European Social Science Data Archives
COS	Center for Open Science
DIOSI	Developing and Implementing hands-on training on Open Science and Open Innovation for Early Career Researchers
DMEG	Data Management Expert Guide
DMP	Data Management Plan
DOI	Digital Object Identifier
DOST	Digital Open Science Tools
EC	European Commission
ECR	Early Career Researcher
EFRC	European Framework for Research Careers
EOSC	European Open Science Cloud
ERIC	European Research Infrastructure Consortium
FAIR	Findable, Accessible Interoperable and Reusable
FOS	Full Open Science
FOSTER	Facilitating Open Science in European Research
GDPR	General Data Protection Regulation
HLEG	High-Level Expert Group
HRS4R	Human Resources Strategy for Researchers
IPR	Intellectual Property Rights
IGDORE	Institute for Globally Distributed Open Research and Education
IDTP	Innovative Doctoral Training Principles
MOOC	Massive Open Online Course
MS	Milestone
OA	Open Access
OER	Open Educational Resource
OPR	Open Peer Review
ORCID	Open Researcher and Contributor IDentifier
OS	Open Science
OSF	Open Science Framework
PID	Persistent IDentifier(s)
QRP	Questionable Research Practices
R1	First Stage Researcher (up to the point of PhD)
R2	Recognised Researcher (PhD holders or equivalent who are not yet fully independent)
R3	Established Researcher (researchers who have developed a level of independence)
R4	Leading Researcher (researchers leading their research area or field)
RDM	Research Data Management
RO	Research Object
RRA	Responsible Research Assessment

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RRI	Responsible Research and Innovation
RRR	Reusability, Replication, and Reproducibility
SSH	Social Sciences and Humanities
TOPS	Transform to Open Science
VRE	Virtual Research Environment
YUFE	Young Universities for the Future of Europe

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YUFE OPEN SCIENCE SYLLABUS

1. Introduction and context

Having OS skills is crucial for new scientists. We cannot blame researchers for not practicing Open Science if we do not train them on how to do it. So, YUFERING WP5 *(Open Science (OS): establishing the new normal)* includes a specific task on engaging and training researchers in OS *(Task 5.4. Co-create a training and engaging scheme for YUFE researchers about Open Science).* This deliverable gathers the results of an exploratory analysis of the intended skills and training activities in Open Science. The analysis includes: the current practices on Open Science education in YUFE member institutions, and on the other hand the main existing educational resources and courses to train researchers to become *"open scientists".* As a result, we want to define a commonly agreed syllabus to train all researchers within the YUFE Alliance. Developing these skills in our researchers is critical for promoting transparency, accountability, and innovation in scientific research. It is essential for researchers in all fields to embrace the principles of open research.

Training researchers to practice OS is one of the main issues in Open Science (OS) implementation. This has been one of the crucial challenges in the European Open Science Agenda since 2016. Likewise, UNESCO[1] recognizes the investment in capacity building and human capital as a critical prerequisite for the operationalization of Open Science and the implementation of the UNESCO recommendation across the world (UNESCO, 2021).

For Open Science to become a reality, researchers need appropriate discipline-dependent skills, training, and professional development at all stages of their careers. In this sense, the European Commission (EC) created in 2017 a High-Level Expert Group (HLEG) on Open Sciences Skills with the specific mandate to propose recommendations to ensure that researchers in Europe have the appropriate skills and competencies to practice OS. The overarching goal of that group has been to ensure that OS skills become an integral and streamlined component of the standard education, training and career development paths of researchers, and if possible even at earlier career stages (O'Carroll et al., 2017). In this deliverable, we assume the same goal: to guarantee that all YUFE researchers have the appropriate skills and knowledge to practice Open Science, assuming at the same time the *European Charter for researchers* in continuing professional development[2]*:*

> *"Researchers at all career stages should seek to continually improve themselves by regularly updating and expanding their skills and competencies.*

[1] Building capacity for open science (UNESCO Open Science Toolkit): https://unesdoc.unesco.org/ark:/48223/pf0000383326

[2] https://euraxess.ec.europa.eu/jobs/charter/european-charter

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This may be achieved by a variety of means including, but not restricted to, formal training, workshops, conferences, and e-learning".

Task 5.4 covers the spirit of the UNESCO Working Group (WG) on OS Capacity Building which highlights the key factors to consider in OS training and capacity building. There are two major **elements of capacity building** for OS[3]:

1. An awareness and understanding of open science itself. In YUFERING we have addressed this element by creating the OS Calendar in 2022 (please see: D5.4. and (Méndez et al., 2022)[4]) and a new version of the calendar for 2023, using AI tools (Sánchez-Moreno & Méndez, 2023), taking into account that the US government[5] and NASA[6] declared 2023 *"The year of Open Science".*
2. The specific skillset, theoretical understanding and resources needed for implementation of the tasks involved in OS. This deliverable (D5.3) focuses on this element of capacity building in OS for YUFE members.

When all researchers are aware of Open Science and are trained, supported and guided at all career stages to practice OS, the potential is there to fundamentally change the way research is performed and disseminated, fostering a scientific ecosystem in which research gains increased visibility, is shared more efficiently, and is performed with enhanced research integrity. It can create unprecedented connections between researchers and the public at large, allowing for a vibrant citizen science practice, poised to have transformative effects on how research is executed (Bezjak et al., 2019; O'Carroll et al., 2017).

2. Scope and methodology

This deliverable aims at creating a common syllabus on Open Science for all members of YUFE universities, in order to create that "master syllabus" to train all our researchers in a common framework of OS. The syllabus could be implemented individually, by each member institution (in their national language) now or in the future, in a common course for all the members, online and in English.

The methodology developed to come up with a common syllabus had two different phases:

1. Benchmarking and analysis of the most important courses and materials already available on the Web. We have identified and focused on the main resources dealing with OS training, namely:
    a) 3 key reports:
        - The report on the HLEG on OS skills (O'Carroll et al., 2017)

[3] https://unesdoc.unesco.org/ark:/48223/pf0000383326
[4] https://zenodo.org/record/5961563#.Y_nsFXaZPIU
[5] https://www.whitehouse.gov/ostp/news-updates/2023/01/11/fact-sheet-biden-harris-administration-announces-new-actions-to-advance-open-and-equitable-research/
[6] https://nasa.github.io/Transform-to-Open-Science-Book/Year_of_Open_Science_Guide/readme.html

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        - The UNESCO toolkit document on capacity building[7]
        - The Open Science Training Handbook (Bezjak et al., 2019)
    b) The 3 more important courses or materials:
        - Opensciency, the core OS curriculum by and for the research community, created in the context of TOPS initiative (Almarzouq, Batool et al., 2023).
        - FOSTER portal[8] in the context of FOSTER projects (2014-2019).
        - The Open Science MOOC[9], a collective endeavour to train OS globally to any researcher of the world (2018-).
2. Analysis of the current training performed at the 10 YUFE universities on Open Science. For this analysis, we have used two surveys:
    - One survey, specifically developed in task 5.4, targeting the people involved in OS training in each YUFE institution (See 3.2.1).
    - The survey developed in task 5.1 about the general perception of OS, targeting YUFE individual researchers. Some questions in this survey focused on the skills in OS that our researchers are missing (See 3.2.2).

The final syllabus will include a set of principles and key factors to be considered in the common training, as well as general learning outcomes, a framework for instructional design, and a master set of topics and themes to be included as content.

3. Education and training in Open Science

3.1. General overview of OS training

In this section, we have identified some of the most important courses and/or training materials about OS that are freely available on the Web, ranging from MOOCs to individual Open Educational Resources (OER), and other initiatives whose purpose is to upskill people in Open Science or relevant aspects of OS.

The list of materials included here is not intended to be comprehensive; we have selected the resources based on: 1) the acknowledgement of the course/material within the OS community and 2) the potential inspiration for the contents of YUFE Open Science syllabus. First, we identify the materials and courses addressing OS complete training, and second, we describe some specific courses focusing on one specific topic (e.g. open data, open access, research integrity, etc.).

3.1.1. Main courses/material addressing OS as a whole

- **Opensciency[10]**

[7] https://unesdoc.unesco.org/ark:/48223/pf0000383326
[8] https://www.fosteropenscience.eu
[9] https://opensciencemooc.eu
[10] The materials developed in Opensciency can be downloaded either from Zenodo or from the GitHub collection of TOPS in: https://github.com/learnopenscience

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Opensciency is the most recent OS curriculum and corresponding material designed by the research community and targeting researchers (Almarzouq, Batool et al., 2023). It is the result of the work of more than 40 OS experts and practitioners from across the world and from different disciplines. The first draft of the curriculum material was developed in the summer of 2022 as part of the Transform to Open Science (Gentemann et al., 2022). After the *TOPS Community Panel*[11] meeting in October 2022 the original contributors created the Opensciency repository to allow all contributors to further engage with the curriculum and invite review of the initial draft material from the wider research community. The reusable material created under Opensciency reflects the OpenCore curriculum agreed upon by TOPS dealing with different key issues of Open Science in a discipline-agnostic focus, and it states in 5 main modules (Figure 1).

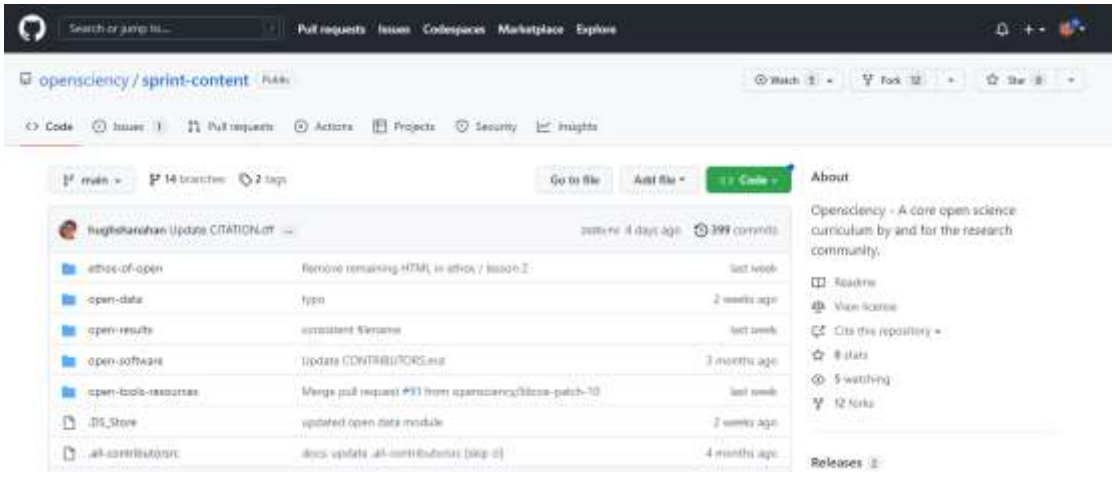

Figure 1. Opensciency sprint content in GitHub[12].

1) *Ethos of Science module:* This is the only required module (2,5 hrs, online or in-person). It will include best practices for building OS communities, increasing collaboration, and introducing open principles to project design, as well as an overview of OS norms. This module will also explore the historical impact of "closed" science and how Open Science seeks to create a more diverse and equitable scientific community.
2) *Open Tools and Resources module*. It is designed to give participants real-world experience working with collaborative tools such as Git, GitHub, and Jupyter Notebooks. This module may need to be updated frequently as tools are constantly changing.
3) *Open Software module* looks at code-centred practices and the impact of choosing open-source code. The module will also include a discussion about the relationship between sharing code and equity.

[11] https://github.com/nasa/Transform-to-Open-Science/blob/main/docs/Area1_Engagement/Community_Panels/readme.md
[12] https://github.com/opensciency/sprint-content

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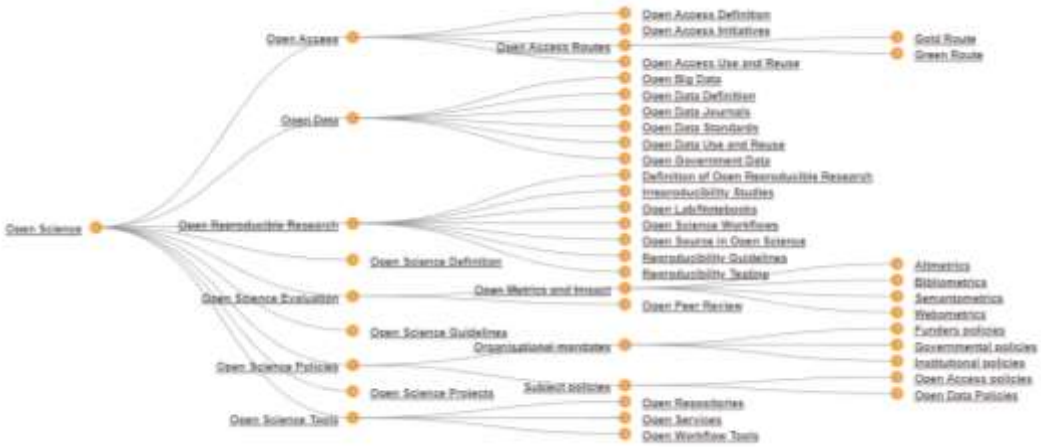
4) *Open Data module* focuses on the best possible data repositories on both ends. Participants will develop a data management plan (DMP) that is useful to researchers, which follows FAIR principles, uses metadata, and cites FAIR data in publications.
5) *Open Results module* covers the use of data repositories (from the perspective of the user and of the contributor). Participants make a DMP that uses license /copyright, metadata tagging, and the assignment of persistent identifiers (PIDs).

Opensciency material seeks to be reused by the community and has a space in GitHub to communicate a creative approach to displaying and reusing the material, which would help to improve and collectively co-create materials addressing the intended topics of the OS curriculum[13].

- FOSTER Open Science.

FOSTER (Facilitating Open Science in European Research) is a very well-known community and portal, created under two EU-funded projects (FOSTER and FOSTER+) from 2014 to 2019[14]. The project partners and community have created an amazing set of courses and resources to learn Open Science, collected in a portal[15]. The FOSTER portal is an e-learning platform that brings together the best training resources addressed to those who need to know more about Open Science, or need to develop strategies and skills for implementing Open Science practices in their daily workflows. The portal gathers a growing collection of training materials and courses targeting different users or stakeholders: from early-career researchers to data managers, librarians, research administrators, and graduate schools. All the training materials are conceived as particular free courses addressing different classified aspects of OS, and mapping to the also well-known FOSTER taxonomy on Open Science (Figure 2).



[13] https://github.com/opensciency/sprint-content/issues
[14] https://openscience.eu/foster-open-science
[15] https://www.fosteropenscience.eu/courses

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Figure 2. FOSTER's taxonomy on Open Science.

Along with the comprehensive collection of free courses, the FOSTER project developed the Handbook that we have already mentioned, helping trainers and institutions to design and perform courses in Open Science (Bezjak et al., 2019). Focusing on the taxonomy, FOSTER's handbook identifies the "Open Science" which are the most relevant 12 aspects or components of OS: 1) Open Concepts And Principles; 2) Open Research Data And Materials; 3) Open Research Software And Open Source; 4) Reproducible Research And Data Analysis; 5) Open Access To Published Research Results; 6) Open Licensing And File Formats; 7) Collaborative Platforms; 8) Open Peer Review Metrics And Evaluation; 9) Open Science Policies; 10) Citizen Science; 11) Open Educational Resources; and 12) Open Advocacy The main courses addressing these important aspects of Open Science are collected in FOSTER portal in a so-called FOSTER Open Science Toolkit that includes 12 courses. Each course takes about 1–2 hours to work through, and you'll receive a badge upon completion. The courses include practical tips on getting started with OS, as well as providing information on discipline-specific tools and resources each learner can use. There is no specified order through the courses, and the learners can choose their own pace.

- Open Science MOOC

This was a collective endeavour led by Jon Tennant in 2018 to create a free Massive Open Online Course on Open Science. It is based on the MOOCs philosophy, including different modules and having a collective learning approach. More than an Open Online Course, it was defined as an Open Online Community (Tennant et al., 2019). This project was carried out almost entirely by volunteer work. There were 12 people on the Steering Committee, as well as a core Production Team and Advisory Network, both of which were open to anyone to join. The MOOC was developed in Eliademy platform[16], and it has a modular design for the learners to create their own self-paced training. The modules conceived as individual mini-courses are Open principles, Open collaboration, Reproducible research and data analysis, Open research data, Open research software and open source, Open Access to research papers, Open evaluation, Public engagement with science, Open educational resources and Open advocacy. In February 2022, the course was moved to another collective initiative, IGDORE[17] (Institute for Globally Distributed Open Research and Education).

There are also training endeavours in OS created by a particular country (Open Science Fellows Program (Germany) Open Science - Open Learning Course (Finland) or a particular institution: Open Science in Practice (created by Max Planck Digital Library) or Open Science: Sharing Your Research with the World (by TUDelft). Other courses target a specific collective (e.g. Early Career Researchers) like Eurodoc OS Ambassadors Training, or very specific topic or domain like the Ornithology's "Citizen Science" course (created by CornellLab).

[16] https://elearningindustry.com/directory/elearning-software/eliademy
[17] https://igdore.org

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3.1.2. Other courses/material addressing particular aspects or elements of OS

There are many courses, materials or resources, ranging from F2F training initiatives to MOOCs or other OERs, focusing on one particular topic or in a particular domain, or even a particular topic (like FAIR open data) in a particular domain (like SSH[18] or life sciences). UNESCO has created an index of courses and materials by topic called **Capacity Building Index** (Figure 3a[19]) and under each category one can find a comprehensive list of courses in that topic conveniently described and detailed, or use the search interface (Figure 3b[20]). .

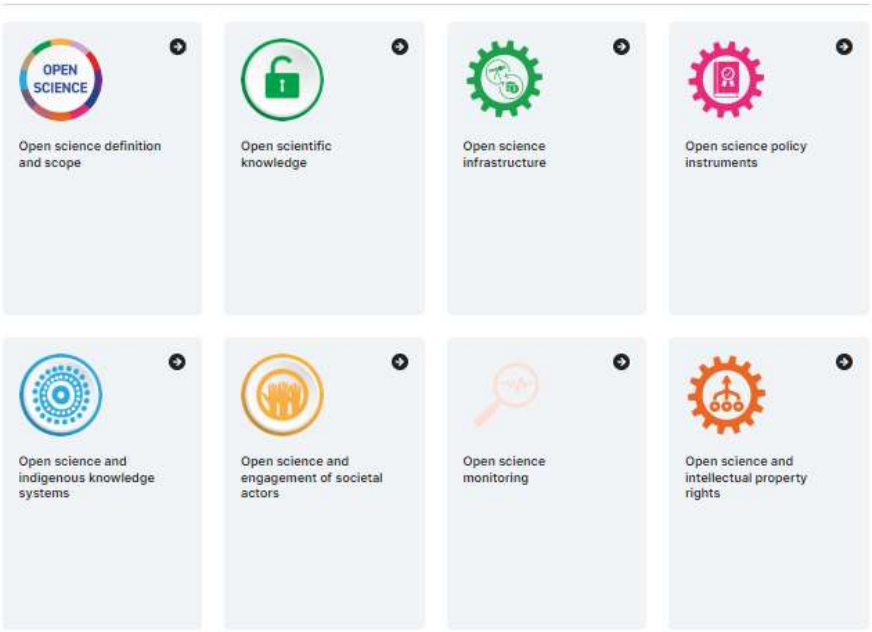
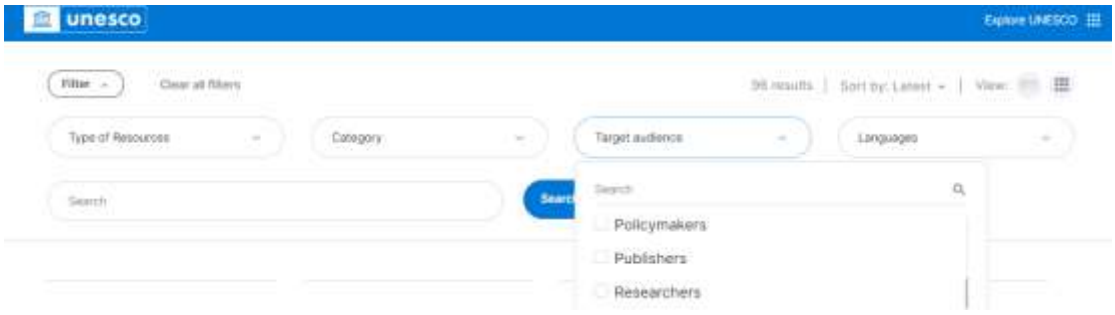


Figure 3a. Categories of the UNESCO OS Capacity Building Index.



[18] This is, for example, the case of the Data Management Expert Guide (DMEG) developed by CESSDA ERIC targeting Social Sciences: https://dmeg.cessda.eu or Elixir Data Management and Data Stewardship in Life Sciences: https://elixir.mf.uni-lj.si/enrol/index.php?id=78

[19] https://www.unesco.org/en/open-science/capacity-building-index

[20] https://www.unesco.org/en/open-science/grid?hub=686

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Figure 3b. Search interface/filters of the UNESCO OS Capacity Building Index.

There are also several courses and resources very well-known addressing one particular topic or element of OS, for example, related to data management or reproducibility.

- **Data Management,** examples include:
  - Data Carpentry initiative, developing and teaching workshops on the fundamental data skills needed to conduct research. It provides researchers with high-quality, domain-specific training covering the full lifecycle of data-driven research.
  - Coursera's course on Research Data Management and Sharing. This was one of the first MOOC created and offered on the Coursera platform about data sharing and management. It has different editions, and it runs over four weeks and modules including videos, readings, and exercises.
- **Citizen Science**, examples include:
  - EU-citizen science training platform. It is a complete platform for training and learning citizen science, developed in Moodle as part of the eu-citizen science project, where we can find all kinds of courses addressing citizen science
  - Citizen Science Projects: How to make a difference (MOOC in Future Learn). This MOOC was developed by the University of Dundee and aims at learning how to build a citizen science project to address global challenges and create a positive change. It is a 4 weeks introductory course.
  - Citizen Science: gearing up for discovery. It is also a MOOC developed on the edX platform by the University of Baltimore and the University System in Maryland. It is a self-paced free course of 6 weeks that covers the North-America approach to Citizen Science.
- **Reproducibility,** examples include:
  - Openness and reproducibility research practices training. The Center of Open Science (COS) has developed this robust, hands-on, pragmatic curriculum, curated from use cases developed in collaboration with the community of open researchers to navigate the complex world of reproducibility.
  - ReproducibiliTea. Started in 2018 at the University of Oxford, reproducibility is a grassroots "journal club" initiative that helps researchers create local OS journal clubs at particular universities to discuss diverse issues, papers and ideas about improving science, reproducibility and the Open Science movement (e.g. Open Science Journal Club at the Bordeaux Neurocampus Graduate Program),
  - Coursera's course on Reproducible Research. This MOOC, designed by Johns Hopkins University, runs also for 4 weeks and focuses on the concepts and tools that enable researchers to perform reproducible data

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analysis. Reproducible research is based on the idea that data analyses, and scientific claims more generally, are published with your data and software code so that others can verify and build on the findings.

3.2. Skills and education in Open Science @YUFE universities

3.2.1 Current education in Open Science at YUFE members

Here we want to provide an overview of the current picture of Open Science education in the YUFE Alliance members in order to identify the major coincidences, common topics, as well as particularities of each institution that could benefit the others. To this end, a survey was sent to all the partners involved in YUFERING, namely: the University of Rijeka; the University of Cyprus; Universidad Carlos III de Madrid; Nicolaus Copernicus University; Maastricht University; the University of Antwerp; the University of Eastern Finland; the University of Rome Tor Vergata; University of Essex, and the University of Bremen. The survey was answered by specific people involved in OS training at each institution. Eleven answers were collected during the first three months of 2022; among these, one institution from the previous list provided more than one reply, while another did not respond.

After descriptive information, the survey consisted of 9 main questions about the training in OS performed at each YUFE university. Here below, we analyse the results by individual questions.

Q1: What topics does your institution provide training on? (Choose all that apply)

In this question, the respondents had 17 options to choose from. Looking at the answers provided, we can say that “Open Data” and “Open Access (publishing in journals and monographs)” represent the main topic on which our universities provide training, followed by “Research visibility” and “Open Access (archives and repositories)”. Themes such as “Persistent identifiers (e.g. DOIs, ORCID)”, “Open Science policies”, “Research Data Management/Data Management Plan”, and “Copyright” turn out to be averagely spread among most YUFE members. At the same time, “Online Research Profiles” and “Citation metrics” have been selected only four times.

YUFE partners seem not to pay great attention to “Open Innovation”, “Pre-registration of studies”, and “Citizen studies” since they have been selected only twice, but also “Responsible metrics” and “Altmetrics” are rarely included within the training provided (Figure 4,5).

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Figure 4. Topic training provide by YUFE institutions.

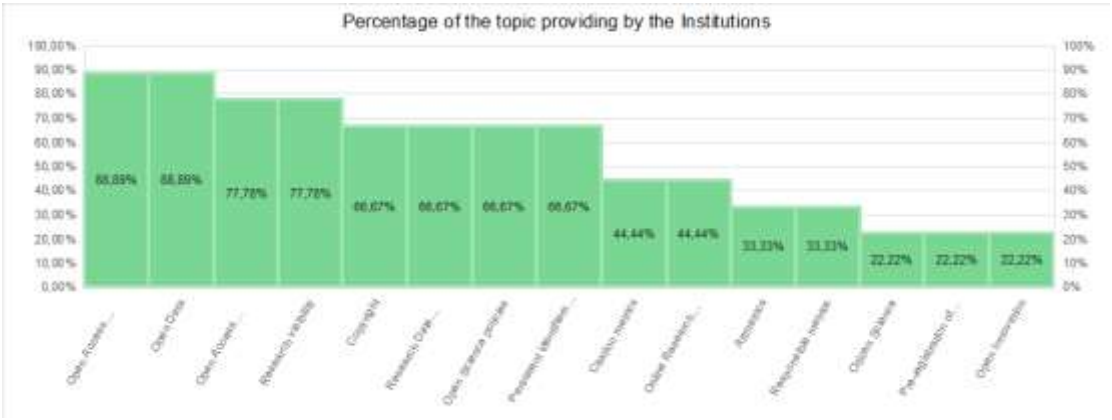

Figure 5: Percentage of the topic provided by YUFE institutions.

Q2: Who do you provide these sessions for?

Question number 2 aimed to understand who are beneficiaries of the training provided. It was a closed question, and the participants had to choose between the following options: Professional Services staff; Academic staff/research staff; Postgraduate staff/students (PhD level); Postgraduate students (Master level); Undergraduate students (Bachelor level).

Data shows (Figure 6) that such training on OS mainly addresses academic and/or research staff and graduate and postgraduate staff/students (PhD level), who are the individuals that are mostly interested in OS at our universities. In several cases, the training is also provided for graduate students (Master level), and more rarely for professional services staff or undergraduate students (Bachelor level).

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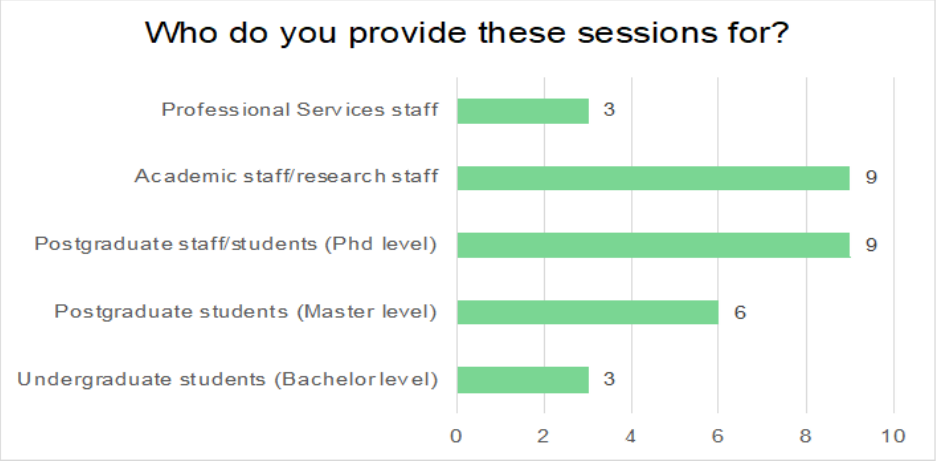

Figure 6. Groups targeted in OS training in YUFE institutions.

Q3. Who provides training on Open Science at your institution? (Choose all that apply)

In this question, we wanted to know the profiles of the trainers, who are the people in charge of the training. It was a closed question with these options: Librarians; Research Support Staff; Researchers; PhD staff/students; External experts.

Looking at the answers, shown in Figure 6, we can state that, among the YUFE Consortium, most of the training on Open Science is provided by Librarians (39.13%) and Researchers (26.09%). Another portion (21.74%) is supplied by External experts and, in very few cases, by Research Support Staff. The training is not provided by PhD staff/students at any of our universities.

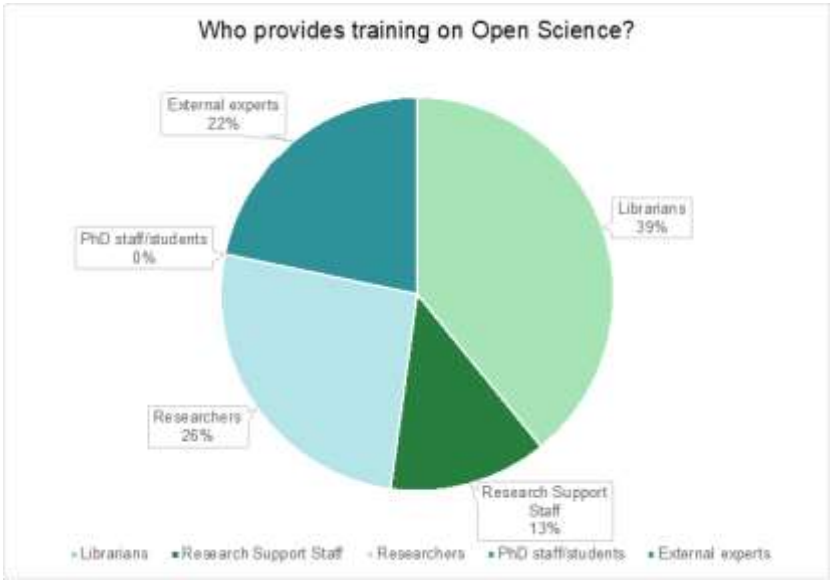

Figure 7. Profiles of the trainers in YUFE institutions.

Q4. Are sessions tailored to a subject area? (for example, Humanities, STEM)

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Question number 4 verifies whether the sessions provided are thought to be customized to specific areas.

The results (Figure 8) reflect that the sessions provided tend not to be customized to specific areas: 55.56% of the respondents replied “Sometimes or on demand”, 33.33% “No”, and only 11.11% replied affirmatively.

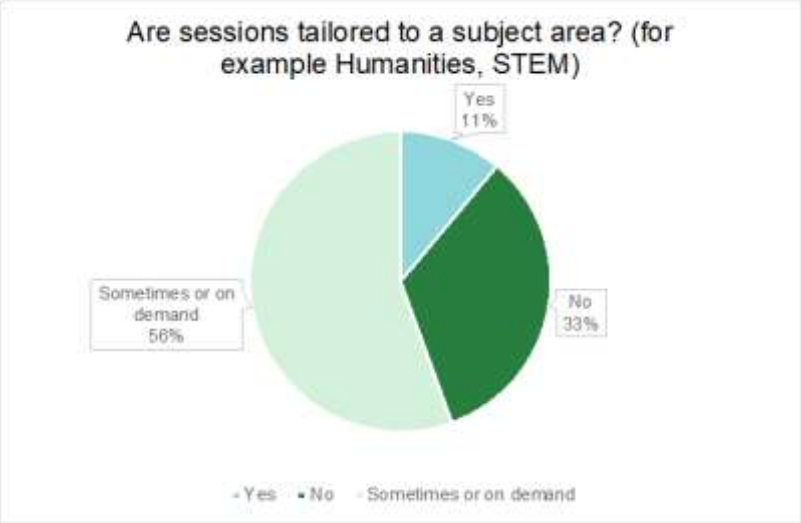

Figure 8. Training in OS tailored by discipline.

Q5. Do you have any other comments or information you would like to add about the training you deliver around open science?

Question 5 was an open question to let the participants add further information about any concerns they may have with the training they deliver, and only two institutions responded. We found that Universidad Carlos III de Madrid delivers training in English or Spanish depending on the audience, and also in English when the training includes guest speakers/experts. The University of Eastern Finland (UEF) provided the link https://www.uef.fi/en/library/courses-and-training-provided-by-uef-library in which the courses and training provided by the Library are available.

Q6. How is training delivered at your institutions (Tick all that apply)?

Number 6 was another closed question, investigating the methodologies/tools used by the institutions to provide their training. The options given were: Face-to-face; Online; e-learning; Workshop; other.

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Figure 9. OS training delivery model in YUFE institutions.

Looking at the answers (Figure 9), we can see that the training is delivered in different formats, the most common being face-to-face and online (27% each), with workshops (21%) and e-learning materials also developed.

Q7. Does your institution provide any open educational resources on Open Science, either hosted at the institution or as a part of another community/network?

As we have seen in the previous section, this exists already, as a lot of material is published on the Web as Open Educational Resources (OER). For example, the Open Science MOOC and all the courses listed under FOSTER or Plato catalogue. This question aimed to find out if our YUFE institutions provide, or point out to, these OERs within their institutions to facilitate self-paced learning among the community. Most (7 of 12) replied yes; two of them were “not sure”, one answered negatively, and another institution didn’t respond (Figure 10).

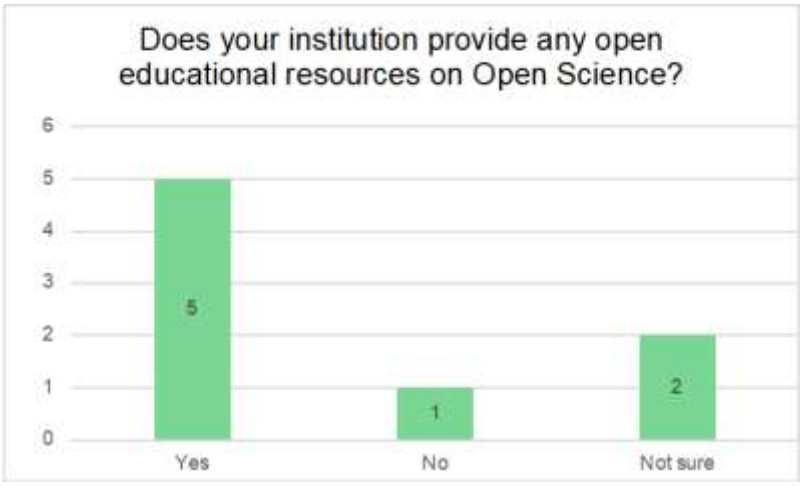

Figure 10. External material and or OERs provided.

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Q8. Do you have any links to information or resources from your institution on Open Science that you want to highlight and share?

Question number 8 verifies if the participants have links, information, or resources on Open Science useful to highlight and share.

The answers obtained are in line with the solutions from the previous question: the same institutions that have confirmed to provide educational resources on Open Science declared to have links, information, or resources to highlight and share. In contrast, the same institutions that responded negatively to question number 7 didn't have materials to highlight or share. Also, on this occasion, one institution didn't reply.

Q9. If yes, could you please provide more information (for example, links to the resources)

The last question aims to collect more information on the material that the partners could share. All the universities answering the survey shared links related to their training/materials, both in English and in the national languages (Annex 1 provides a collection of links with information about the courses by YUFE member institutions).

3.2.2 Expectations of training from researchers in YUFE

Under the work done in Task 5.1, we conducted another survey in 2022, this time targeting research-active staff (*N* = 548) within the YUFE University members to evaluate their general engagement with Open Science practices. Among other questions, we ask our researchers to identify any areas in which they may require further training.

Concerning their actual knowledge of Open Science, we first evaluated participants' familiarity with common OS practices. The particular question posed was: *"How would you rate your knowledge of the following open science practices?"* The results, shown in Figure 11, indicated that researchers were highly knowledgeable about where to publish open access and how to make manuscripts openly available. They also demonstrated a relatively high level of knowledge about repositories for data and materials sharing and how to use them. While slightly over 50% said they were at least moderately knowledgeable about preparing data and materials for public sharing, the majority of respondents claimed that they lacked knowledge in navigating relevant legislation and selecting and applying for open resource-sharing licenses. The areas in which participants exhibited the least amount of knowledge were participatory research methods and pre-registration protocol preparation.

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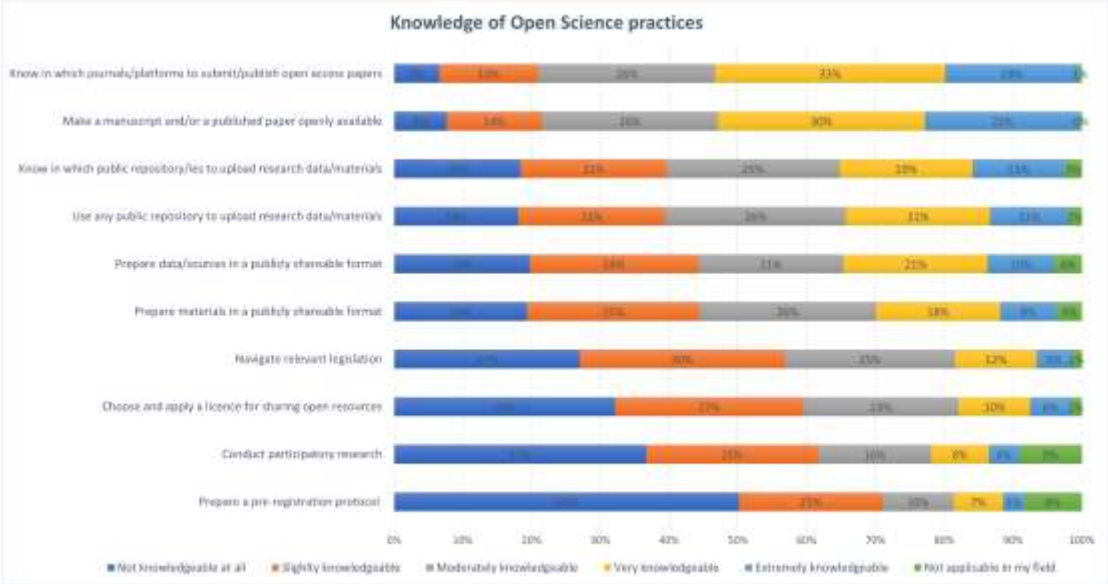

Figure 11. Current knowledge of Open Science practices among YUFE researchers.

In addition to assessing researchers' knowledge of OS practices, we also evaluated their interest in learning about specific activities. The particular question here was, *"Which of the following open science practices would you like to know more about?"* This complemented the knowledge question, as researchers may lack knowledge about a particular practice but still not have the desire to learn more about it. Our findings, depicted in Figure 12, indicate that navigating relevant legislation and choosing and applying for a license were the most desired areas of knowledge to learn. Respondents also expressed a strong desire for training on preparing materials and data in a publicly shareable format and how to conduct participatory research. Additionally, over 60% of respondents expressed interest in learning how to prepare a pre-registration protocol, as well as which public repositories to use and how to use them for sharing data and materials publicly. The two least popular areas of interest were making manuscripts openly available and knowing which journals publish open-access papers. Overall, respondents expressed a strong desire to learn about a broad range of open science practices, with written guidance being the preferred format for most topics. However, topics such as legislation and participatory research may require workshop-led training for effective delivery.

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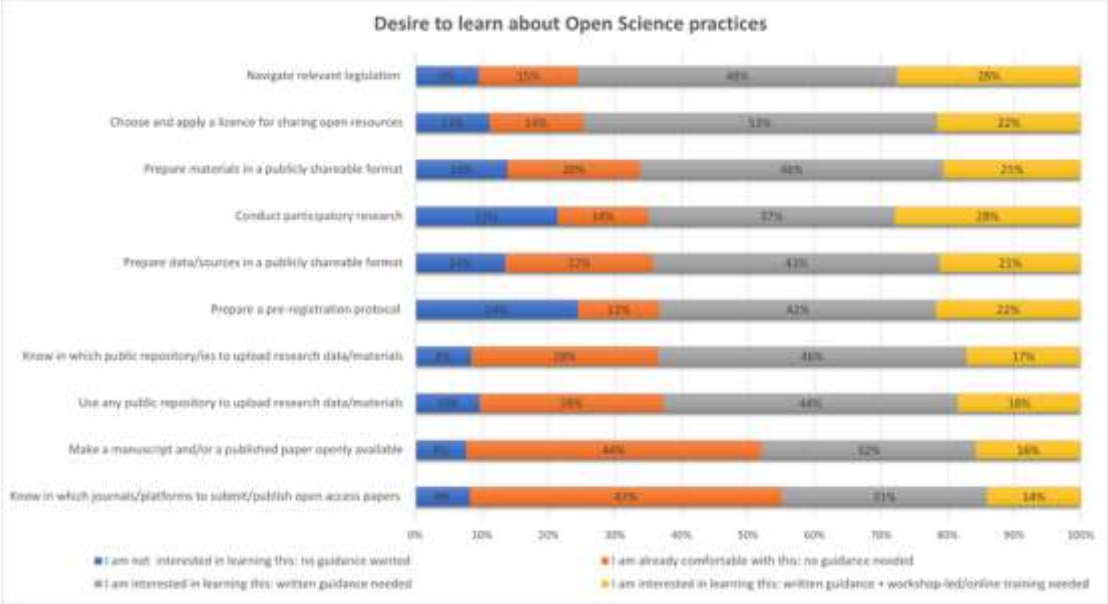

Figure 12. Open Science practices that YUFE researchers would like to learn more.

Based on the results, the integration of these training topics and content into the YUFE OS syllabus should be considered, to support the development of OS skills among our researchers to cover their expectations and training needs.

4. YUFE Open Science syllabus for our researchers

A good syllabus should provide students or learners with a clear understanding of what will be covered in the course, what they are expected to learn, how their performance will be evaluated, and what is expected from them regarding their engagement and participation in the course, in order to assess their learning. However, for this first iteration of our syllabus, it is important to state that it is not intended to be a full-fledged final syllabus. There is still room for improvement, adaptation, and evolution since OS tools and initiatives evolve over time very quickly, and we will keep incorporating content, materials, references, and ideas. Each institution will decide on particular aspects, e.g. the format of training, the dates (when applicable) as well as specific assessment.

3.1. Principles and key factors

We detail here below the principles and key factors for our OS syllabus and training that should be considered for our instructional design framework.

1. YUFE syllabus will include both “principles” and “practices” of OS (Bezjak et al., 2019):
    - Principles include increased transparency, re-use, participation, cooperation, accountability, and reproducibility for research; and it aims to improve the quality and reliability of research through inclusion, fairness, equity, and sharing.

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- Practices include changes to the way science is done: data-sharing, open notebooks, transparency in research evaluation, ensuring the reproducibility of research, transparency in research methods, pre-registration (when appropriate), open access to research publications and FAIR data, open source code, software and infrastructure, citizen science and open educational resources.

2. The YUFE syllabus targets all the research career levels (R1-R4): First Stage Researchers (R1 – up to the point of PhD) and Recognised Researchers (R2 – PhD holders or equivalent who are not yet fully independent), and Established Researchers (R3 – researchers who have developed a level of independence) and Leading Researchers (R4 – researchers leading their research area and field)[21].

   In the future, it will be interesting to focus on Early Career Researchers (ECR) and PhD students, since they could be future trainers. The OS course for PhD students might be seen as a train-the-trainers course, since they could replicate the training. As we mention in 3.2.1 none of our universities provides OS training by PhD staff/students and ECRs, who are also recognised as crucial members for implementing the cultural change that OS needs.

3. Our syllabus is domain-agnostic and could be valid for all disciplines[22]. In the future, or "on-demand", YUFE institutions should provide disciplinary-oriented training since different disciplines might have different specific needs in terms of practices and tools.
4. The master content aims to reflect: 1) what we currently teach in our institutions (3.2.1), 2) what YUFE researchers miss in their skills and knowledge related to OS (3.2.2) for example, legal issues, and 3) all the general trends on OS training (3.1).
5. We want to consider for our syllabus all the particularities that we are developing in YUFERING related to Open Science (WP5) to introduce them in our Open Science course(s), i.e. how to become a FOS (Full Open Science) research team (Task 5.3) or gamification of learning (MS10[23]).

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[21] https://euraxess.ec.europa.eu/europe/career-development/training-researchers/research-profiles-descriptors

[22] In this sense, we have taken into account the reflection on FOSTER Open Science Training Handbook: As "Open Science" is the more common term, we shall use it here, but it should be read as referring to research from all scholarly disciplines ranging from Life and Physical Sciences, Engineering, Mathematics, Social Sciences and Humanities (Bezjak et al., 2019).

[23] Gamification of OS training is one of the identity signs of our OS training at YUFE institutions, and MS10 includes a collection of games and resources to learn by playing OS. This collection is included in Zenodo with the title: "YUFERING OS games". It can be accessed here: https://zenodo.org/record/7680290#.Y_xyYXbP2Uk. The game library includes links to different games to learn particular aspects of OS (copyright, Open Access, RRA, etc.); some of them created by YUFE members, but also a collection of other games that might be improved and completed by the Community in the future. As part of this project, a new game was also developed by the University of Essex specifically for YUFERING. This is *The Open Science Files*, and it is accessible via Figshare: https://doi.org/10.6084/m9.figshare.22109870.

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6. We have taken into account the criteria established in YUFERING (Task 5.3) to become FOS research teams, and also the criteria included in the OS-CAM (OS-Career Assessment Matrix) defined by the EC HLEG (O'Carroll et al., 2017). Including the criteria related to OS that the researchers might be assessed for is a good motivation for learning.
7. We reflected on, and adapted for our training activities and YUFE OS syllabus, the key factors identified by UNESCO to design capacity-building activities and training materials to boost OS. These key factors are:
    - *Awareness of existing materials.* We will consider existing courses and resources instead of building a new training program from scratch. We have considered all the resources included in 3.1.
    - *Adaptability and reuse:* The aim is not to duplicate, but to enrich materials with context and content. Re-use will always be facilitated by open licensing, the use of editable formats and the integration of training materials into standard learning management systems. For example, if we reuse the materials of Opensciency content creative, we will contact the community as it is stated[24].
    - *Flexibility*: Different pathways of transition to and practice of OS need to be encouraged among YUFE members, while upholding the core values and maximizing adherence to the shared principles of OS. Each institution might adapt the contents to the diversity of science systems, as well as the evolving nature of the supporting information in this field.
    - *Engagement of the target audience*: our initial target audience are our YUFE individual researchers at any career level. To facilitate their engagement, instructors and facilitators should be available to the students/learners over a sustained period of time or even through Open Science Units or services. Also, a certification or a digital open badge should be implemented to recognize the competencies attained by the researcher who received the training. In our case, we will include the acknowledgement of the training in the FOS badge.
    - *Sustainability*: The sustainability of the capacity building and training efforts will be boosted in YUFE member institutions by effectively storing and sharing the results and records of those efforts, particularly when connecting institutional trainers with readily available training materials. Since our syllabus targets 10 different EU countries, mapping the master content into OS national frameworks would be recommended.
    - *Inclusiveness:* OS, in the base of UNESCO recommendation, should embrace inclusive education and diversity of knowledge, practices, workflows, languages, research outputs and research topics that support the needs and variety of the scientific community as a whole. Even when our researchers among the 10 YUFE institutions might seem

[24] https://github.com/opensciency/sprint-content

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very comparable, diversity in research cultures might appear and must be considered and adapted in each country, also paying attention to the different ages and gender of the scholars.

- *Multilingualism and localization:* Considering that the YUFE Alliance implies 10 universities in 10 different countries with different national languages, we must consider translating the materials.
- *Accessibility:* Our training, courses and materials will address "accessibility" in the broadest sense of UNESCO recommendation: the courses will be openly available as OER to be part of the knowledge commons or public domain materials. The courses and materials themselves should be FAIR which means that they will have the needed persistent identifiers, metadata, vocabularies and licenses to make them (as much as possible) findable, accessible, interoperable and reusable. Archiving options of the course should also be explored and implemented to guarantee the storage and maintenance of the material over time. Finally, "accessibility" must consider a range of users in a variety of contexts, using diverse sets of methods of teaching and learning, both physical and digital for both in-person and virtual settings, including subtitles, sign language translations, etc. where appropriate.
- *Monitoring and evaluation:* our courses and materials must consider different metrics to monitor trainers and trainees by country or region, gender, age range, primary language and career level. Monitoring and engagement must be aligned. It is valuable to engage with the OS community to identify ongoing efforts and needs to adapt accordingly the syllabus to the context, discipline or institutional setting.

3.2. Learning outcomes

The YUFE Open Science Syllabus is designed to reflect the following essential learning outcomes:

1. Develop an appreciation for the significance of OS practices for conducting informative and transparent research while maintaining research integrity.
2. Acquire a comprehensive understanding of the spectrum of OS activities, along with the necessary tools for implementing them.
3. Develop practical skills necessary for implementing effectively different OS practices.
4. Gain the ability to apply the acquired knowledge and skills in real-world research contexts.

Overall, these learning outcomes aim to equip learners with the fundamental understanding, tools, and practical skills required to foster an open and transparent research culture that upholds research integrity. Each module or lesson will also have its particular learning objectives.

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3.3. Instructional design (framework)

As mentioned above, Open Science is an emerging paradigm that demands from researchers a wide range of skills. There are gaps currently in the European classifications and competencies for Open Science, for example, Open Science is largely missing from the *Digital Skills Competence.* Creating guidelines to implement OS was recommended, which includes a revision of the major European Guidelines and Frameworks concerning researchers' skills and career development to include Open Science, i.e. the *European Framework for Research Careers* (EFRC[25]), the *Human Resources Strategy for Researchers* (HRS4R[26]), and the *Innovative Doctoral Training Principles* (IDTP[27]). This also includes the development of FAIR institutional guidelines, in particular for Open Access publications and Open Data (O'Carroll et al., 2017).

Moreover, it is not just that there is no Open Science competence framework available, but all those competent frameworks are under revision. As a consequence, it is not a simple task yet to identify the core competencies that any Open Science syllabus must cover. Neither is it simple to propose learning outcomes and objectives aligned to a syllabus, nor to speak of contents of a programme and their educational materials or of summative or formative assessment methods.

When it comes to pointing out the principles of any instructional design, the model suggested by Gagne, et al. (2005) is usually one of the most frequently mentioned. These are the following:

- Gain attention
- Inform the learner of the objectives and expected outcomes
- Stimulate recall of prior learning
- Present stimulus and engaging material
- Provide learner guidance
- Elicit performance
- Provide feedback
- Assess performance
- Enhance retention and transfer

The YUFE Open Science syllabus needs to be learner-centred (understanding the researcher as a learner in this case) in such a way that new skills (the ones required by OS) are actually built on the existing ones (the mere research skills). However, Open Science can be conceptualised as a layer over the research process, and its competences must be part of the general research ones. The final goal is to understand that there is no other science than Open Science. Hence, OS skills are just enhanced

25 http://ec.europa.eu/euraxess/pdf/research_policies/Towards_a_European_Framework_for_Research_Careers_final.pdf

26 https://euraxess.ec.europa.eu/jobs/hrs4r

27 https://euraxess.ec.europa.eu/sites/default/files/policy_library/principles_for_innovative_doctoral_training.pdf

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researchers' skills. A culture change is therefore the ultimate desired outcome of this process.

Applying the principles of instructional design to the YUFE Open Science syllabus, it is crucial to take two levels into consideration. On the one hand, the design of the whole program; on the other, the design of each one of the modules integrated into the syllabus. There will be researchers interested in a complete training, whereas some might focus on specific content to address their specific needs. It could be interesting that each module, or part of the syllabus, is designed as a self-sufficient or stand-alone module.

A YUFE Open Science syllabus must consist of:

- A clearly defined program with a global view of the skills and learning outcomes that need to be developed.
- A set of modules with specific contents addressing specific learning outcomes and skills, such as: Open Science in the research cycle; Open Access publishing; Research Data Management (RDM); Open (FAIR) data; IPR issues, copyright and Open Licenses; Citizen Science; Research Integrity; Responsible Research Assessment (RRA); Online research profiles: visibility and persistent identifiers; Open innovation and entrepreneurship; Open Science tools.

Each module must include a consistent design of the program, educational materials, learning activities and formative and summative assessments, which should:

- Guide the learning process thoroughly.
- Recall prior knowledge related to the topic addressed.
- Apply the new knowledge to questions, problems, or cases immediately afterwards:
    - The more challenging the activities, the deeper the learning process.
    - If possible, team activities or engagement through discussion forums could be helpful.
- Provide positive feedback to keep learners engaged and motivated to revisit those learnings that might be incomplete or inaccurate.
- Assess the knowledge step by step, so the learning progress is gradually checked out.
- Encourage the application of new skills to real research situations or contexts.

3.4. Master content and topics

This course provides an introduction to Open Science principles, practices, and tools. The syllabus content is designed for researchers at all levels who are interested in adopting Open Science practices in their research.

We cover the most common topics included in the 3 main training resources considered (Opensciency, OS Science MOOC, and FOSTER's Handbook (Figure 13) complemented by the topics already covered in the current OS training for YUFE members (Cf. 3.2.1, Annex 1) plus the topics that our researchers would like to be trained on (Cf. 3.2.2).

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Figure 13. Tagcloud of the main topics covered in Opensciency, OS Science MOOC, and FOSTER's Handbook (Wordclouds).

The content covers all the skills identified by HLEG on OS Skills (O'Carroll et al., 2017) and grouped in four big groups:

- Skills and expertise necessary for open access publishing.
- Skills and expertise regarding research data, data production, management, analysis/use/reuse, dissemination and a change of paradigm from "protected data by default" to "open data by default", respecting legal, and other constraints.
- Skills and expertise to act in and beyond one's own scholarly and disciplinary community.
- Skills and expertise resulting from a general and broad concept of citizen science, where researchers interact with the public at large to enhance the impact of science and research.

Considering all these recommendations, training initiatives, plus our researchers' needs, the contents of our courses, to be included in YUFE OS Syllabus are:

Module 1: Ethos and Introduction to Open Science

- What is Open Science and what does it promote
- Historical development of Open Science
- Benefits of Open Science for researchers and society
- European and International policies to promote Open Science
- Open Science components and challenges

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- Performing Open Science responsibility
- Including OS in the whole research cycle
- OS Communities
- Practice/activity: Open Science café discussion[28]. The OS café will serve as the starting point for creating the University Open Science Community[29].

Module 2: Open Research Results

- The (open) research cycle and its results
- Collaborative approaches in the research cycle
- Results in the context of OS
- Applying Open Results Framework and selected tools to support OS
- Attribution and credit of the Open Results. Open license
- Practice/activity: Introduction to OSF[30] (Open Science Framework)

Module 3: Open Access Publishing

- What is open access publishing
- OA history and declarations: 20 years of OA
- Types of open access publishing: Routes
- PlanS & cOAlition S, transformative agreements and current trends.
- Types of OA repositories. Know your institutional repository
- Self-archiving policies
- Diamond OA initiatives
- Benefits and challenges of OA publishing.
- Predatory journals and how to recognise them
- Practice/Activity: Open Access Escape Room[31]. The practice under this module will include to self-archive one of their current publications being aware of the policies in Sherpa/Romeo, or other local websites (e.g. Dulcinea in Spain).

Module 3: Open Peer Review

- What is Open Peer Review (OPR)
- OPR workflows

[28] This is a game included in YUFERING Open Science game library (https://zenodo.org/record/7680290#.Y_2X53aZPIX) created under DIOSI project to discuss Open Science with doctoral candidates, but it can be adapted and enriched to discuss Open Science with any researcher. DIOSI project is another YUFE project targeting training for ECR. See: https://diosi.eu

[29] Maastricht is the only member than has already created this kind of communities, and could help YUFE members, within YUFERING, as a role-model for OS communities' creation. https://www.openscience-maastricht.nl

[30] https://osf.io

[31] OA Escape Room (https://figshare.com/projects/Open_Access_Escape_Room/56915) is a game developed by one of the YUFE members, the University of Essex, to understand and play with Open Access. It has to be f2f activity, but we will work on an online one. This game can be also found in the YUFERING OS game library, pointed out before.

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- Discipline specific journals, pre-print servers & OPR initiatives (F1000/ORE platforms, Publons-WOS , ScienceOpen, Winnower)
- Benefits and challenges of OPR: quality, dissemination, credit, collaboration
- How to write a good OPR report
- Activity/Practice: Check different OPR systems. For this practice the researchers might be divided into disciplines to better analyse their own domain practices.

Module 4: Open Research Data, FAIR data and Data Management Plans

- What is Open Data, Open Research Data
- (Inter)national regulations and the current policies for data sharing. EU Directive 1024/2019
- GDPR and data protection
- FAIR data principles and CARE data principles
- Metadata and PIDs
- Types of row data (qualitative and quantitative)
- How to prepare and share data: create a DMP (Tools)
- Best practices for data management: managing Research Data responsibly
- Current data repositories and EOSC (European Open Science Cloud). Trusted Repositories.
- Activity/Practice: Each learner will create a DMP for one of their current research projects using one of the provided tools in this module (DMP online, Argos or any other local developed tool).

Module 5: ELSI issues: Ethical, Legal and Social Issues of OS.

- IPR (Intellectual Property Rights) and Open Science
- Copyright exceptions: Rights Retention Strategy, Secondary copyright
- Knowledge valorisation and Open Innovation
- Types of open licenses
- Choosing a license for your Research Objects: publications, software, data
- Ethics in Open Science:
    - Responsible Research and Innovation
    - Code of Conduct of Research
    - Research Integrity
- Activities/Practices: 1) Each student will choose licenses for their current or pretending Research Objects (RO). 2) Play Dilemma Game (online/app): The Dilemma Game[32] confronts researchers with difficult dilemmas in the context

[32] https://www.eur.nl/en/about-eur/policy-and-regulations/integrity/research-integrity/dilemma-game Dilemma Game can be played with the app, online or through printed cards. Students/researchers are facing different ethical issues related to their (open) research. This game is also part of the collection of YUFERING OS game library in Zenodo.

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of a critical dialogue, supporting them in further developing their own 'moral compass'. Students will play in groups in the class.

Module 6: Citizen Science (CS)

- What is citizen science. History and evolution of CS
- Citizen Science and public engagement: difference and confluence
- YUFERING approach to citizen science: CERI (Community Engagement Responsible Research and Innovation
- Citizen science principles (10) and characteristics.
- Types of citizen science projects
- CS platforms and communities (CitizenScience toolkit, SciStarter, national CS platforms and communities)
- Create your own project of CS
- CS in educational settings: Open Educational Resources and citizen science
- Activity/Practice: 1) Quiz about what is and what is not citizen science. 2) Each student could find and analyse a CS project of their discipline.

Module 7: Open Science Tools and Resources

- Overview of Open Science tools
- Analysis of tools for each of the steps in the Research cycle (101Tools-Utrecht and DOST (Digital Open Science Tools):
    - Reference management and discovery tools
    - Tools for analysis
    - Collaborative writing platforms and other tools to produce content (DMP, presentations, pre-prints, etc.)
    - Annotation and review tools (PubPeer, Hypothes.i, PaperHive)
    - Outreach: tools to promote your research and visibility
- Collaborative platforms and VREs (Virtual Research Environments)
- Activity/practice: The students/learners will register in at least three of the tools showed in the module and practice with them.

Each YUFE university could add these optional modules on reproducibility if they have researches attendees in the course affected (e.g. psychology, neuroscientist, healthcare research, etc. computer scientists, or other collectives that might have software as a RO).

Module 8 (optional): Pre-registration and Reproducibility

- Reusability, Replication, and Reproducibility (RRR)
- Reproducibility crisis and National Reproducibility Networks and initiatives
- Challenges in reproducibility: publication bias, QRP (Questionable Research Practices, etc.)
- Best practices on improving reproducibility

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- Concept of preregistration and disciplines that practice pre-registration
- Design a pre-registered study.
- Pre-registration platforms and templates (Aspredicted, OSF, etc.).
- Tools for improving reproducibility: RMarkdown, Jupyter notebook, etc.
- Activity/practice: 1) Hands-on exercise in data management for successful reproducible research. 2) Hands-on pre-registration or registration of an individual research

Final Project: Students will apply the concepts and tools learned in the course to their current research and will present their findings in an openly available collective blog or another open platform (e.g. GitHub[33] or OSF, Open Science Framework[34])

5. Conclusions and future work

The work done in Task 5.4 so far, and all the reflections included here in this deliverable, drive us to several conclusions:

- There is a huge plethora of online courses and resources available for self-paced learning in OS in general, as well as in particular issues like reproducibility or RDM. However, researchers need support during the learning process.
- All YUFE member institutions provide training in Open Science for their researchers. However, this attempt at a common syllabus will allow us to improve and align our training activities to better upskill our researchers.
- Each institution should decide on different questions to adapt the syllabus and the content. Some of these open issues to be decided in each institution are:
    - The training language. It might be more suitable to train in the national language. However, doing it in English will reach international researchers at YUFE member institutions. Performing the training in English will also permit us to re-use already existing materials and "share alike" ours.
    - The training modality. After the pandemic, online training has become more and more common, and it implies more flexibility for attendance. However, a combination of F2F with online sessions could be the perfect model.
    - Research levels and modules. Each institution might decide to target the YUFE OS training to a particular research career level. Nevertheless, putting ECRs and seniors in the same room (or virtual room) will ignite and foster discussion.
    - Disciplinary-oriented content is another issue to be decided at each institution. It could maintain the core content (domain-agnostic) adding some targeted sessions by discipline, or establish practical work in the course in groups by domain.

[33] https://github.com
[34] https://osf.io

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Future work under YUFERING Task 5.4 might include a further discussion about the possibility, advantages, and disadvantages of converting this syllabus and training reflections on a common only YUFE Open Science course, perhaps conceived as a MOOC-like course for YUFE researchers. In that case, another pending question would be to decide which platform[35] to use and how to conceive the course. We will also work with the project Skills4EOSC dealing with creating the minimum viable skillsets and certification mechanism for OS training in Europe.

[35] Some platforms to consider are here https://www.courseminded.com/tools, but also it might be considered OpenPlato (https://openplato.eu), a platform specifically developed for OS training in the context of OpenAire infrastructure.

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ANNEX 1: Links with information about current courses by YUFE member institution

YUFE member	Links to educational material/ training in OS
Maastricht University	https://library.maastrichtuniversity.nl/research/rdm/services-tools-training/ https://graduateschool.library.maastrichtuniversity.nl/
Nicolaus Copernicus University	https://moodle.umk.pl/BU/course/view.php?id=14 https://www.bu.umk.pl/plan-zarzadzania-danymi-badawczymi-dmp https://www.bu.umk.pl/copyright,https://www.bu.umk.pl/cytowania http://pomocnik.pon.edu.pl/index.php/pomocnik https://moodle.umk.pl/BU/course/view.php?id=8 https://www.bu.umk.pl/orcid
Universidad Carlos III de Madrid	https://www.uc3m.es/openscience/formacion https://www.uc3m.es/pdi/OpenScienceCafe https://www.curatore.es/uc3m2OpenScience https://www.uc3m.es/ss/Satellite/OpenScience/_/TextoMixta/1371322836892/
University of Antwerp	https://www.uantwerpen.be/en/centres/antwerp-doctoral-school/doctoral-study-programme/training-offer/course-offer-ads/4200ads004/ https://www.uantwerpen.be/en/centres/antwerp-doctoral-school/doctoral-study-programme/training-offer/course-offer-ads/4200ads001/
University of Bremen	https://www.uni-bremen.de/en/research/research-profile/open-access-at-the-university-of-bremen https://www.youtube.com/watch?v=Z9A1vAciTcY https://www.youtube.com/watch?v=Ksz-rOUtIDU https://www.uni-bremen.de/fileadmin/user_upload/forschung/Open_Science/Open_Acces_Policy_EN.pdf https://www.uni-bremen.de/en/forschungsdatenmanagement https://ml.zmml.uni-

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YUFE member	Links to educational material/ training in OS
	bremen.de/video/magic/3w1khjzuaneogs0kg8k8wws48osokgo https://www.uni-bremen.de/fileadmin/user_upload/forschung/Divers/Empfehlungen_zum_Umgang_mit_Forschungsdaten.pdf https://www.bremen-research.de/data-train/
University of Cyprus	https://training.ni4os.eu/course/view.php?id=92 https://gnosis.library.ucy.ac.cy/handle/7/39728
University of Eastern Finland	https://www.uef.fi/en/open-science-and-research https://www.uef.fi/en/datasupport https://www.uef.fi/en/library/courses-and-training-provided-by-uef-library https://blogs.uef.fi/ueflibrary-bors https://sites.uef.fi/rdm https://blogs.uef.fi/ueflibrarypostgrad https://www.uef.fi/en/library/information-retrieval-and-training#paragraph-4154
University of Essex	https://library.essex.ac.uk/open-research https://library.essex.ac.uk/open-research/open-access-publishing https://library.essex.ac.uk/copyright-guide https://library.essex.ac.uk/ressup-home https://figshare.com/projects/Copyright_Dough/76128 https://doi.org/10.6084/m9.figshare.22109870
University of Rijeka	https://sites.google.com/view/edudoc-svkri/edukacije/open-science/copyright-and-open-licensing
University Roma Tor Vergata	http://opendataspa.uniroma2.it/wp-content/uploads/2019/06/coppolacerruti.pdf https://e-archivo.uc3m.es/bitstream/handle/10016/29263/tor_coppola_OSISW_2019.pdf?sequence=1&isAllowed=y https://web.uniroma2.it/it/contenuto/open_access https://web.uniroma2.it/en/percorso/homepage/sezione/research__science_and_knowledge

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