

OPEN EDUCATIONAL RESOURCES ON OPEN SCIENCE AND RESPONSIBLE RESEARCH AND INNOVATION (OPEN RRI)

C. Lagido¹, K. Nielsen¹, G. Kragh¹; P. Flohr², L. Bezuidenhout², L. Brinkman³, A. Baini⁴, C. Saviane⁴, A. Salnikova⁵, A. Brandstetter-Kunc⁵, G. Consolini⁶, A. Correia⁷, P. Moura⁷, M. Fedeli⁶, J. England⁸, S. Venkataraman⁸, A. Skarvøy⁹, T. Konach⁹, B. Taraj⁹, K. Koller¹⁰, I. Marschalek¹⁰, M. Schrammel¹⁰, S. Jurković¹¹, B. Macan¹¹, A. Vodopijeve¹¹, B. Cahill¹², A. Giraldo Sevilla^{13, 15}, N. Pitrelli⁴, A.L. Spera¹⁴, C. Iasillo¹⁴, P. Príncipe⁷, N. De Lorenzo⁶, M. Haklay¹³

¹Aarhus University (DENMARK)

²Leiden University (NETHERLANDS)

³Data Archiving and Networked Services (DANS) (NETHERLANDS)

⁴Scuola Internazionale Superiore di Studi Avanzati (SISSA) (ITALY)

⁵Fondation Européenne de la Science (ESF, FRANCE)

⁶Università Vita-Salute San Raffaele (UniSR) (ITALY)

⁷Universidade do Minho (UMinho) (PORTUGAL)

⁸OpenAIRE AMKE (GREECE)

⁹European Association of Research Managers and Administrators (EARMA) (BELGIUM)

¹⁰Zentrum Für Soziale Innovation GMBH (ZSI) (AUSTRIA)

¹¹Ruder Bošković Institute, University of Zagreb (RBI) (CROATIA)

¹²Stichting SciLink (SciLink) (NETHERLANDS)

¹³Learning Planet Institute (LPI) (FRANCE)

¹⁴Agenzia per la Promozione della Ricerca Europea (APRE) (ITALY)

¹⁵Université Paris Cité (UPC) (FRANCE)

Abstract

This paper presents key findings from a large mapping exercise of open educational resources in Open Science and Responsible Research and Innovation (Open RRI), carried out by the EU-funded PATTERN project. Using a mixed-method approach, we collected and assessed information on over 500 training resources across eight Open RRI skill areas through collaborative knowledge gathering, desk research, and surveys. Our quality assessment of approximately 250 digitally and freely available resources within Open RRI considered relevance, accessibility, ease of implementation, structure, and description quality, aiming to identify strengths, weaknesses, and gaps for potential reuse and new training opportunities.

We discuss our key findings across eight Open RRI skill areas. In Open Access (OA), we identified 16 course and 18 non-course materials, focusing notably on beginners, with gaps identified in predatory publishing, repositories, specific routes for OA, and funder requirements. For Findable, Accessible, Interoperable, and Reusable (FAIR) Data Management, 23 course and 39 non-course materials were collected, mainly for beginners, revealing a gap in advanced-level training materials, particularly in controlled vocabularies, metadata standards, and long-term curation, as well as training for laypersons. Citizen Science resources encompass 54 courses and 55 non-course materials, emphasizing introductory levels and broad audiences, with gaps identified in advanced-level training, diversity and inclusion, institutional change, and fundraising. Research Integrity resources include 16 courses and 16 non-course materials and more from The Embassy of Good Science Platform, highlighting gaps in intellectual property, research collaborations, privacy, confidentiality, and Open Science training. Gender, Non-discrimination, and Inclusion in research resources cover 20 courses and 44 non-course materials, with gaps beyond Gender Equality Plans, insufficient attention to gender-based violence, and a need for more advanced-level training tailored for trainers and educators, as well as tools for self-awareness of bias/privilege and action tools. Dissemination and Exploitation of Results resources include 22-course offerings and 13 non-course materials, primarily targeting beginners and all researchers/academics, revealing gaps in intermediate and advanced-level resources, particularly in intellectual property and business plans, and social, cultural, and economic impact. Science Communication (towards media and policymakers) included 99 courses and 15 non-course materials, mostly designed for beginners with paid access, with identified gaps in advanced levels, engagement

with policymakers, Artificial Intelligence communication, diversity and inclusion, communication of uncertainty, and data visualisation courses. Management and Leadership resources, comprising 36 course and 11 non-course materials, covered diverse topics but revealed a gap in addressing mentor-mentee relationships and networking, crucial for researchers' professional development.

Our work offers a comprehensive view of existing high-quality resources in Open RRI training, acknowledging the dynamic nature of the field. Challenges such as limited information on in-person training, language barriers, and gaps in certain areas highlight the need for continuous mapping efforts and ongoing crowdsourcing to address evolving training landscapes and enhance accessibility and inclusivity.

Keywords: Open Science (OS), Responsible Research and Innovation (RRI), Mapping exercise, educational resources, transferable skills, quality, gap analysis.

1 INTRODUCTION

The European Research Area (ERA) aims to promote sustainability, digitalisation, and resilience. Research and Innovation in Europe are anchored in shared values that include freedom of scientific research, the pursuit of excellence, ethics, integrity, inclusiveness, gender equality, value creation, and societal responsibility [1]. Integral to this is the promotion of Open Science (OS) and Responsible Research and Innovation (RRI) [2]. This places a focus on training and lifelong learning, to equip researchers with the competencies and skills essential for engaging with society effectively. Not only will upskilling foster public trust in science but it will also enhance integration of researchers into the labour market, promoting a robust knowledge-based economy.

Aligned with the Horizon Europe framework and the European Skills Agenda, the project 'Piloting open and Responsible Activities and Trainings Towards the Enhancement of Researchers Networks' (PATTERN) endeavours to reinforce OS and RRI practices (Open RRI). It prioritises eight key skill areas for training: Open Access (OA); Findable, Accessible, Interoperable, and Reusable (FAIR) Data Management; Citizen Science (CS); Research Integrity (RI); Gender Equality, Dissemination and Exploitation of Results; Science Communication (SC); and Leadership and Management, including Mental Health. These transferable skills serve as pillars to align research and innovation outcomes with societal values, needs, and expectations. Moreover, upskilling will contribute to research environments that are more open and collaborative, hopefully increasing the reproducibility of results.

PATTERN comprises 19 partners from 14 countries. Within this consortium, thematic leaders provide expert guidance in key skill areas (Table 1). Fourteen pilot organisations are also included, tasked with testing the developed training, which is aimed at researchers at all career stages, including master's students, doctoral students, post-doctoral researchers, and established researchers. Some training will also be suitable for bachelor students.

*Table 1. Expertise of PATTERN partners in the eight transferable skill areas.
See authors' affiliation list for full names of organisations.*

<i>Training area</i>	<i>Thematic leaders</i>
Open Access (OA)	OpenAIRE
FAIR Research Data Management (RDM)	DANS, OpenAIRE
Citizen Science (CS)	AU, LPI
Research Integrity (RI)	EARMA, UniSR, AU
Gender Equality, non-discrimination and inclusion in research	ESF, UniSR
Dissemination and Exploitation of Results	APRE, LOBA
Science Communication (SC)	SISSA, AU
Leadership and Mental Health	SciLink

Central to the PATTERN project was an evaluation of the existing training opportunities and policy frameworks at various levels: institutional, national, and European [3,4]. Here, we report on our mapping and quality assessment of existing training opportunities, led by Aarhus University (AU). This evaluation serves a dual purpose: discerning gaps that point to the need for new training activities and establishing a knowledge base that informs the design, implementation, and evaluation of training. Through its

comprehensive approach, PATTERN seeks to enhance the ERA's capacity to address societal challenges, promoting transparency, inclusivity, and sustainability.

2 METHODOLOGY

In evaluating current OS and RRI training programmes and resources, we utilised a mixed-methods approach that included desk research, data sprints, a survey, interviews, and mutual learning events (MLEs), followed by a quality assessment. This approach leveraged the collective knowledge of the consortium and captured information and insights from various stakeholders. The steps of our methodology are described below.

2.1 Mapping gap analysis of training activities

2.1.1 Mapping process

The foundational step of the mapping process consisted of establishing standardised definitions for RRI skills. Desk research, complemented by collaborative data sprints, hosted by AU online, served as primary mechanisms for resource aggregation. These data sprints, conducted in hour-long sessions dedicated to each of the transferable skill areas of PATTERN, facilitated the systematic collection of training resources and descriptive metadata in an Excel spreadsheet. The project adopted the Research Data Alliance (RDA) recommendations on minimal metadata for learning resources [5], with some adjustments. Metadata encompassed a spectrum of descriptors, including title, authorship, language, keywords, URL, licence, access rights, learning resource type, target audience, expertise level, and learning outcomes. Additional metadata collected included: organisation/provider, content description, content themes (skills trained)/curriculum, duration, training mode, and learner assessment, as inspired by the EU-funded TIME4CS project [6]. Furthermore, controlled vocabularies were employed to ensure consistency and facilitate machine readability, thus enhancing the interoperability and accessibility of the compiled dataset.

2.1.2 Survey

A supplementary component of the data collection phase involved a survey disseminated through the professional networks of all consortium partners. The survey, hosted on the SurveyXact platform, featured a suite of questions aimed at elucidating prevailing training needs and discerning valued aspects within Open RRI. Prior to dissemination, the survey was discussed and improved with input from the project partners and received ethical clearance from the Research Ethics Committee at Aarhus University.

2.1.3 Interviews

Interviews were carried out with key stakeholders, including opinion leaders, scholars, and trainers in relevant domains. These semi-structured interviews, conducted by AU and Scuola Internazionale Superiore di Studi Avanzati (SISSA), provided key qualitative insights and complemented the information on training and training gaps. Similarly to the survey, the interviews gained ethical clearance from AU. Most interviews were conducted online, while two were in person. Interviews were recorded with the consent of the participants and transcripts were automatically generated by MS Teams or audio files were imported into Otter.ai for transcription. The interviewer used the transcripts along with any notes taken during the interviews, to create interview summaries, highlighting the main points made and the information obtained.

2.1.4 Mutual Learning Events

An important feature of the PATTERN methodology was to conduct MLEs as forums for knowledge exchange, collaborative learning, and engagement with other projects and communities of practice. Facilitated by the Centre for Social Innovation (ZSI) and engaging all the consortium partners and their networks to recruit participants, the MLEs were conducted in three sequential iterations, designed to progressively deepen the dialogue and extend the geographical reach of the participants. Each event featured interactive sessions, group discussions, and plenary presentations, aimed at understanding current trends in face-to-face, online and asynchronous learning, and emergent practices.

2.2 Quality assessment

The quality assessment of training resources was structured according to the transferable skill areas identified within the PATTERN project. Each area was assigned to a respective partner responsible for conducting the evaluation according to the agreed quality criteria outlined below. Due to accessibility issues, only digitally available and open-access resources were evaluated. In addition, only resources suitable for a researcher or research support staff training were evaluated. Resources tailored for other audiences such as secondary school teachers or the general public were excluded from consideration.

2.2.1 Quality Criteria

The quality assessment process was guided by a set of predefined criteria adopted from the EU-Citizen. Science project, a Horizon 2020 initiative focused on citizen science training. These criteria, which have been co-created within the above project, encompassed resource accessibility, readability, clarity of objectives, ease of implementation, and overall impact, as well as prior evaluations of training resources and their potential or actual impact on science, policy, or society [7].

2.2.2 Quality Assessment Process

The resources selected for quality assessment were evaluated by the thematic leaders joined by UMinho, RBI, and ZSI, based on the outlined quality criteria, with scores assigned on a scale ranging from very poor to very good. Furthermore, an in-depth analysis was conducted to assess strengths, weaknesses, and opportunities, considering factors such as interactivity, coverage of important topics, and the addressing of known gaps in training (as informed by the content themes of mapped resources, survey, interviews, and mutual learning events).

3 RESULTS

3.1 Mapped training resources

PATTERN identified more than 500 training resources in different transferable skill areas of Open RRI (Fig.1). The consortium devoted a significant effort to this task. The mapping of resources concentrated on the first six months of the project, with another two months needed for the completion of metadata entry. Fig. 1 shows the total number of resources identified per skill area. The training was divided into two categories: 1) courses, e-learning modules, and workshops and 2) supporting non-course training materials such as recorded webinars, guidebooks, websites, etc. Generally, similar numbers of course-type training and non-course training materials were identified, except for Gender equality, non-discrimination and inclusion in research, with approximately twice as many non-course training materials, and Science Communication (towards media and policymakers), with a predominance of course-type training.

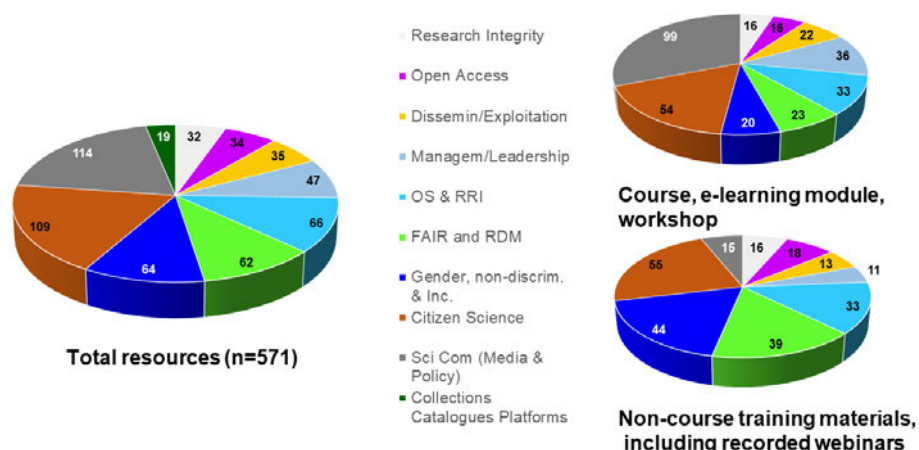


Figure 1. Training resources in Open Science (OS) and Responsible Research and Innovation (RRI) mapped by PATTERN. Eight skill areas were mapped: Open Access, FAIR Research Data Management, Citizen Science, Research Integrity, Gender Equality (non-discrimination and inclusion in research), Dissemination and Exploitation of Results, Science Communication (towards media and policymakers), and Management and Leadership (renamed as Leadership and Mental Health). In addition, general training in OS and RRI was mapped, as well as collections, catalogues and platforms (e.g. The Embassy of Good Science, a research integrity resource with multiple courses, was mapped as a platform)

Some of the areas with a greater number of identified training opportunities, such as Citizen Science and Science communication, benefited from the mapping efforts of previous European projects such as EU-Citizen. Science and TIME4CS, and QUEST and GlobalSCAPE. Meanwhile, the number of training resources identified in Research Integrity (shown in Fig. 1) would be considerably higher if the courses and materials that are part of the Embassy of Good Science Platform had been counted individually [8].

The greatest majority of mapped training opportunities were in English (n=471), with 29 in Italian, 22 in German, 17 in French, and a combined total of 32 resources in other languages that included Croatian (8), Spanish (6), Portuguese (4), Finnish (4), Greek (3), Dutch (2), Hungarian (2), Swedish (1), Norwegian (1), and Slovak (1). This language distribution likely reflects the dominance of English as an international language and the common language of the consortium.

3.1.1 Expertise level of training resources mapped

Across most skill areas, we encountered a common pattern of good availability of training for beginners and all audience levels (Fig. 2). Some areas like Citizen Science, Research Integrity, and Leadership and Mental Health also cater for the intermediate level. Leadership and Mental Health had the highest proportion of advanced training. In contrast, in many areas, there was a shortage of intermediate and advanced-level training.

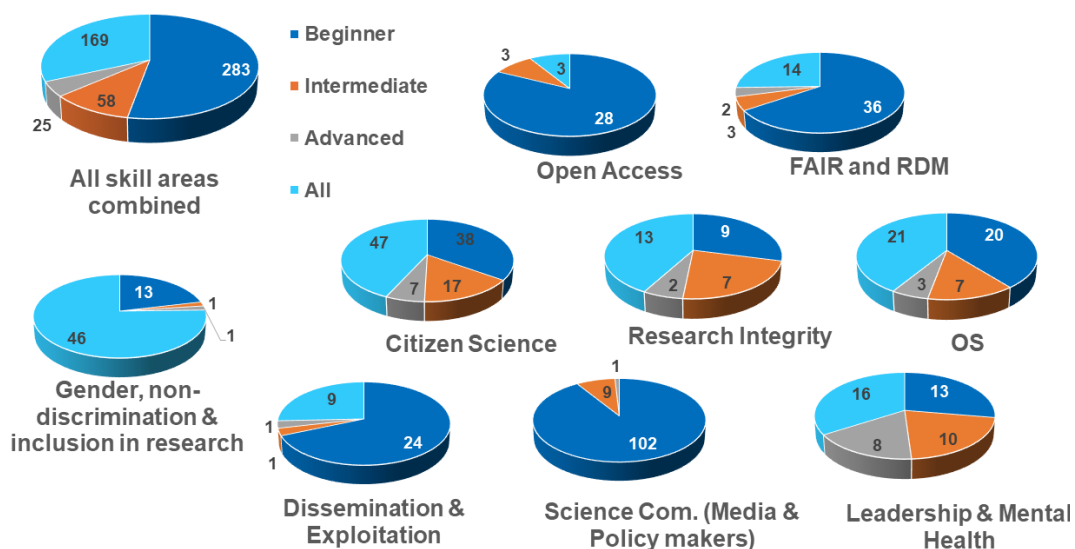


Figure 2. Expertise levels of training in the various transferable skill areas mapped by PATTERN. The expertise levels included beginner, intermediate, advanced; or suitable for all.

3.1.2 Gaps identified

Through the analysis of the content themes of available training, the collective knowledge within the consortium and aided by MLEs, several gaps in training were identified within each skill area, summarised in Table 2. Moreover, gaps in training concerning all areas included the intersection with diversity and inclusion as well as local and indigenous knowledge, multi- and interdisciplinarity training, interactive training, such as problem and project-based learning, and train-the-trainer. As noted in the previous section, there is generally a gap in more advanced level training and a need to better define the training needs of advanced learners.

Table 2. Content gaps were identified in training across the eight PATTERN transferable skill areas.

Training area	Training content gaps identified
Open Access (OA)	Funders' requirements; repositories and predatory journals; specific routes of OA; Open peer review developments; Licences; OA definition and OA initiatives, Legal issues
FAIR Data Management/Research Data Management (RDM)	Standards, processes, and curation; foster data reusability; data sensitivity; training for lay persons/citizens

Citizen Science (CS)	Intersectionality between CS and other training areas; CS policies, guidelines and fundraising; roadmaps for implementation of CS by organisations; domain specific training in CS; interaction with the private sector; projects involving citizens as collaborators and co-creators
Research Integrity (RI)	Intersectionality between RI and the following: OS, climate change and environment, inclusion, social consequences of research misconduct; Intellectual Property, authorship, research collaborations, and power dynamics in collaborations and supervision; privacy and confidentiality; focus on domains beyond life and health sciences; emerging topics (e.g. artificial intelligence)
Gender Equality, non-discrimination and inclusion in research	Inclusion topics beyond gender equality plans (GEP) e.g. gender-based violence, evaluating implementation and practical outcomes of GEPs, and dimensions of Diversity and Inclusion beyond Gender; self-awareness of bias/privilege and action tools; and gender agnostic matchmaking tools for collaboration
Dissemination and Exploitation of Results	Social, cultural, and economic impact; writing for the public and industry; broad audience talks; peer to peer events and knowledge exchange platforms
Science Communication (towards media and policymakers)	Inclusivity; uncertainty and the current limits of scientific knowledge; engage policymakers, how to write effective policy briefs; social media, including engine optimisation and analytics; data visualisation; fake news/misinformation and disinformation/pseudoscience; SC basics for all researchers, including 2-way dialogue; theory in SC; methods and tools to track impact, policy and social influence
Leadership and Mental Health	Mentor-mentee relationships; addressing the networking gap, i.e., establishing connections with peers, mentors, and industry professionals; mental health

3.2 Quality assessment of training resources

Digitally and freely available resources aimed at or suitable for researchers were quality assessed (Fig. 3). Through this process, PATTERN identified resources that are suitable for re-use in training and that also provide suitable asynchronous further learning opportunities. PATTERN is also disseminating selected resources of high quality by creating booklets that can be accessed on the PATTERN project website [9].

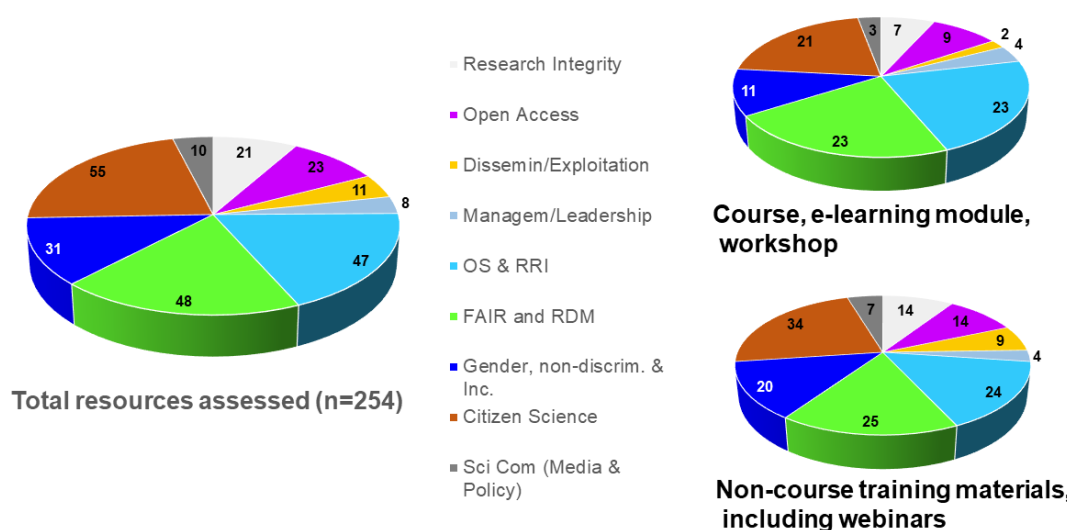


Figure 3. Number of training resources selected for quality assessment in the various transferable skill areas mapped by PATTERN. Selection criteria were accessibility, audience, and ability of PATTERN partners to understand the language.

4 CONCLUSIONS

Using multiple methods and strongly relying on a large and diverse group of PATTERN partners, our project mapped and analysed over 500 training resources related to Open and Responsible Research and Innovation. This resulted in the identification of a substantial collection of high-quality training materials for researchers, with a focus on resources that are accessible digitally and are open [3]. The process helped to distil vast information into actionable insights, highlighting areas of strengths and gaps in RRI training. In particular, diversity and inclusion should be embedded in all training. Despite our best efforts, it is important to acknowledge that our findings may not capture all available resources due to

the dynamic nature of the field and potential oversight of less visible materials. Continued vigilance and collaboration with other projects and communities of practice is necessary to uncover emerging and overlooked resources, as well as to extend availability of training offers in languages other than English.

The collaboration with consortium members, training stakeholders, and experts provided valuable perspectives on current practices and emerging trends in Open Science and RRI training [3]. Looking ahead, PATTERN aims to address identified gaps in RRI training not only by developing accessible resources but also by encouraging their use, particularly among Research Performing Organisations, to align with institutional training needs. These efforts set the stage for the current and future phases of our project.

Upskilling in PATTERN's eight skill areas will promote Open Science and Responsible Research and Innovation as well as its quality and impact. There are many ways in which researchers can directly benefit. Firstly, they will be empowered to conduct more open, collaborative, and reproducible research while adhering to ethical principles. Secondly, they may be more aware and responsive to the needs and values of communities. Thirdly, researchers will be able to navigate diverse professional pathways, including roles at the interface between academia and other societal actors. Finally, these skills contribute to building a more inclusive and equitable research environment by promoting gender equality, non-discrimination, and diversity in research practices and outcomes.

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