Module title	**Research workflows**
Module NFQ level (only if an NFQ level can be demonstrated)	
Module number/reference	
Semester (semester1/semester2 if applicable)	
Module credit units (FET/HET/ECTS)	
Module credit number of units	
Module Status [Mandatory (M)/Elective (E)]	
List the teaching and learning modes	Lectures, Tutorials, and Practical sessions using self-directed learning (includes reading and study)
Entry requirements (statement of knowledge, skill and competence)	Internal to the programme
Pre-requisite module titles	
Co-requisite module titles	
Is this a capstone module? (Yes or No)	
Staff qualifications and experience required	Academic and research staff, persons with OS, RDM Experience lecturing in the field.
Staff/student ratio per centre (or module instance)	
Maximum number of students per centre (or module instance)	
Physical resources and support required per centre (or module instance)	TrainRDM platform, Moodle access and support, library access

Analysis of required learning effort

Effort while in contact with staff

Classroom and demonstrations		Mentoring and small-group tutoring		Practical Work		Directed e-learning (hours)	Independent learning (hours)	Other hours (Protected Study Time)	Work-based learning hours of learning effort	Total effort (hours)
Hours	Minimum ratio teacher/student	Hours	Minimum ratio teacher/student	Hours	Minimum ratio teacher/student					

Allocation of marks (within the module)

	Continuous assessment	Supervised project	Proctored practical examination	Proctored written examination	Total
Percentage contribution					

TrainRDM Programme

In drafting the content of the TrainRDM programme, we started with "An overview on Open Science" describing the eight pillars of Open Science identified by the European Commission[1] and used by LERU[2] in their advice paper on Open Science (OS) and the role of universities „A Roadmap of cultural change".

The analysis was followed by a survey of all partners and relevant stakeholders for OS-RDM and topics of interest for TrainRDM. Building upon the Survey results, i.e. the skills needed and suggested by the researchers and the competencies possessed by the differentTrainRDMpartners, it is suggested to develop and, eventually, deliver a full pan-European programme in (Research) Data Management. While the creation of suchprogramme is a long-term aspiration, theTrainRDM will endeavour to develop more training paths (e.g. summer school) that could offer ECTS and/or other certificates such as open badges.

These materials will be used to develop the content of the TrainRDM skills training programme (and its modules) based on the structure proposed by the TraiRDM Toolkit.

Fig.1. 90-credit Pillar MSc in Research Data Management: Proposed Structure.

As detailed in the structure, the 15-credit modules are to be offered by the four HEI members of the TrainRDM Consortium, namely TUW, UPB (with support from ICI), NCI, and Sapienza, and it is planned to also offer the modules as micro-credentials. The 30-credit capstone project will be proposed linked to case studies under the supervision of ICI and DTSL with help from the TrainRDM's HEIs. The entire programme will have a flexible route with joint delivery, leading to a single award. It is duly noted that in European countries, MSc programmes *have typically 120 credits*. As such, there are two elective modules added to cover the additional credits required: "Text and Data Mining" (NCI) and "*Research workflows*" (ICI).

[1] Collected from European Commission – Open Science: https://ec.europa.eu/research/openscience/index.cfm; last accessed 2 May 2018.
[2] League of European Research Universities

1.1. Research Workflows Module Objectives

The module aims to enable learners to understand, discuss, and summarise Research Workflows and Methodologies from an Open Science perspective, providing a concrete context as well as the key points for the most relevant aspects of adopting Open Science as a karma in daily activities related to doing Research and Innovation. Starting from the core concepts and principles of Research Methodology steps, the topics covered by this module continue to address components such as Planning and Designing a Research Study, Data Collection, Assessment Methods and Measurement Strategies, Research Designs and Approaches, Data Preparation, Analysis and Interpretation, Ethical Considerations in Research and Disseminating Research Results. We reiterate that all these topics are approached from an Open Science perspective, meaning the accent leans towards the appropriate use (collect, store, make available) of Open Data, the research data strategies to be followed, publication of results following strict Open Access principles and many others.

The purposes of this Module is, therefore, to discuss the various types of OS research designs that are commonly employed and proposed by different initiatives, the basic process by which research studies are conducted, the OS research-related considerations of which researchers should be aware, the OA manner in which the results of research can be interpreted and disseminated, and the typical pitfalls faced by researchers when designing and conducting an OS research study.

1.2. Intended Module Learning Outcomes

This Module is ideal for those readers with minimal knowledge of research as well as for those readers with intermediate knowledge who need a quick refresher regarding particular OS aspects of research design and methodology. For those readers with an advanced knowledge of research design and methodology, the Module can be used in understanding the differentiators when it comes to conduct an appropriate OS research methodology, and maybe also as a concise summary of basic research techniques and principles. Finally, even for those learners who do not conduct research, this Module can become a valuable addition because it will assist them in becoming more educated consumers of research, to understand the implications of Open Science for research. Being able to evaluate the appropriateness of an OS research design or the conclusions drawn from a particular research study will become increasingly more important as research becomes more accessible to non-scientists (librarians for example). In that regard, this Module will improve the ability to digest and understand the results of a research study and make everyone critical when it comes to OA/OS efficiently and effectively.

Upon successful completion of this module, learners will be able to:

1. Understand the social, economic, legal, and ethical principles and concepts underpinning Open Science Research Methodologies.
2. Understand the relevant elements of Open Data and FAIR principles in applied research methodologies.
3. Demonstrate in-depth knowledge Demonstrate in-depth knowledge of the arguments for and against the inclusion of Open Data in any research methodology.
4. Evaluate and assess software sharing under the most appropriate license (i.e., both the tools and the licensing) when thinking in terms of a research methodology.
5. Understand the necessity of reproducible research and its reasoning.

6. Knowledge to use existing resources to choose an appropriate license for written research work, based on the desired freedom/limitation for others to use/reuse.

1.3. Rationale of the Learning Module

Open Science (OS), the movement to make scientific products and processes accessible to and reusable by all, is about culture and knowledge as much as it is about technologies and services. Convincing researchers of the benefits of changing their practices and equipping them with the skills and knowledge needed to do so, is hence an important task.

Quite frequently these days people talk of OS, both in academic institutions and outside. But many times, when people talk about OS they tend to think of the research implications (e.g. the possibility to publish results in Open Access journals, having access to Open Data), and little attention is paid to an important dimension relating to research, namely, that of Research Methodology. The result is that much of OS research, particularly in engineering, contains endless word-spinning and too many quotations. Thus, a great deal of research tends to be futile. It may be noted, in the context of planning and development, that the significance of research lies in its quality and not in quantity. The need, therefore, is for those concerned with research to pay due attention to designing and adhering to the appropriate methodology throughout for improving the quality of research (and, by implication, of the results obtained). The methodology may differ from the traditional ones (e.g., we need to think in terms of using the right Open Data whenever possible, but also to properly evaluate the Quality of that data and address the specific meta-data describing experimental conditions), even if the basic approach towards research remains the same.

Keeping all this in view, the present Module has two clear objectives, viz., (i) to enable researchers, irrespective of their discipline, in developing the most appropriate OS methodology for their research studies; and (ii) to make them familiar with the art of using different OS research methods and techniques.

In relation to the Minimum Intended Programme Learning Outcomes (MIPLOs), the **Open Science** module specifically contributes to the following MIPLOs:

MIPLO1	Conduct independent research and analysis in the field of Open Science.
MIPLO2	Demonstrate expert knowledge of Open Science.
MIPLO3s	Develop and implement effective business & technical solutions for Open Science.

1.4. Module Content organisation and structure

An indicative schedule of topics to be addressed is outlined below:

1. Planning and Designing an OS Research Study
2. Finding the right Open Data
3. Open Data Collection, Assessment Methods, and Measurement Strategies
4. OS Research Designs and Approaches

5. Sampling Design
6. Measurement and Scaling Techniques
7. Instruments to share Data in Research Methodologies
8. Preparation, Analysis and Processing of Data
9. Data Interpretation and Hypothesis Testing
10. Multivariate Analysis Techniques based on Data Provenance
11. Ethical Considerations in OS Research
12. OA Disseminating Research Results and Distilling Principles of Research Design and Methodology

The mapping between topics and classes is:

ID	Course Title	Topic
Course I (5 ECTS)	Research Data Methodologies	Planning and Designing an OS Research Study
		Open Data Collection, Assessment Methods, and Measurement Strategies
		OS Research Designs and Approaches
Course II (5 ECTS)	Data Collection	Finding the right Open Data
		Sampling Design
		Instruments to share Data in Research Methodologies
Course III (5 ECTS)	Data Analysis	Measurement and Scaling Techniques
		Preparation, Analysis and Processing of Data
		Data Interpretation and Hypothesis Testing
Course IV (5 ECTS)	Data Validation	Multivariate Analysis Techniques based on Data Provenance
		Ethical Considerations in OS Research
		OA Disseminating Research Results and Distilling Principles of Research Design and Methodology

The organisation of the courses is the following:

No.	Course title	ECST	Hours per week				No. of weeks	Total no. of hours				Individual study hours	Form of verification
			Lectures	Applications	Project	Research		Lectures	Applications	Project	Research		
1	Research Data Methodologies	2	2	-	2		14	28	-	28	-	69	Exam
2	Data Collection	2	2	-	2		14	28	-	28	-	69	Exam
3	Data Analysis	2	2	-	2		14	28	-	28	-	69	Verification
4	Data Validation	2	2	-	2		14	28	-	28	-	69	Exam
5	Research&Practice	7	-	-	-	12	14	0	-	-	168	82	MSc Colloquyium
	No. of hours per week per activity	**15**	**8**	**0**	**8**	**12**	**14**						

The definition of he covered topics is the following:

<table>
<tr><th></th><th>Lecture Topic</th><th>Lecture Detail</th><th>Practices (examples)</th></tr>
<tr><td rowspan="2">1.</td><td rowspan="2">Planning and Designing an OS Research Study</td><td>Open Science definition
Research Study definition
Research Topics
Research Problem
Research Design</td><td>Questions, obstacles, and common misconceptions
Exercise:
- Choose a Research Topic
- Formulate a Research Problem
- Choose variables to study</td></tr>
<tr><td colspan="2">Learning objectives:
1. Understand the social, economic, legal, and ethical principles and concepts underpinning Open Science Research Methodologies.
2. Become familiar with the research-related issues that need to be considered during the Planning and Designing stages.
3. Gain an understanding of the basic steps in Planning and Designing an OS Research Study.</td></tr>
<tr><td rowspan="2">2.</td><td rowspan="2">Finding the right Open Data</td><td>Open access
Instruments to collect Open Data
- Content analysis
- Questionnaires
- Interviews
Open Access research infrastructures</td><td>Example exercises:
- Identify new sources of Open Data
- Choose the right instrument to collect Open Data in a given study</td></tr>
<tr><td colspan="2">Learning objectives:
1. Learn about Open access
2. Identifying Open Data sources
3. Proper use of various Open Data collection tools</td></tr>
<tr><td rowspan="2">3.</td><td rowspan="2">Open Data Collection, Assessment Methods, and Measurement Strategies</td><td>Open Data definition
Methods of Data Collection
Assessment Methods
Measurement Strategies
- Measurement
- Scales of Measurement
- Scaling Techniques
- Research principles for open research</td><td>Explore different methods of Open Data Collection, Assessment Methods and Measurement Strategies
Exercise:
- Identify the Methods of Data Collection
- Choose the right Assessment Method
- Choose the right Measurement Strategy</td></tr>
<tr><td colspan="2">Learning objectives:
1. Gain an understanding of arguments for and against the inclusion of Open Data in any research methodology.
2. Gain an understanding of the Methods of Data Collection.</td></tr>
</table>

	Lecture Topic	Lecture Detail	Practices (examples)
		3. Learn about the different options a researcher has when deciding what Assessment Methods and Measurement Strategies to use. 4. Understand the importance of appropriate Assessment Methods and Measurement Strategies to use.	
4.	OS Research Designs and Approaches	- Types of experimental validity and the potential threats (sources of artifact and bias) associated with each - Approaches for controlling artifact and bias General Types of Research Designs and Approaches - Experimental Designs - Quasi-Experimental Designs - Nonexperimental or Qualitative Designs	Explore different OS Research Designs and Approaches Exercises: - Choose approaches for controlling artifact and bias - Choose Research Designs and Approaches
		Learning objectives: 1. Understand the potential threats for design and the approaches for controlling artifact and bias. 2. Gain an understanding of the General Types of Research Designs and Approaches. 3. Understand the importance of appropriate type of design.	
5.	Sampling Design	Implications of a sample design Steps in sample design Criteria of selecting a sampling procedure Characteristics of a good sample design Types of sample designs Random sample	Example exercises: - How to select a random sample? - Choosing the appropriate sampling design
		Learning objectives: 1. Understanding the importance and implications of a sample design; 2. Learn about the different steps in sample design; 3. Using different criteria of selecting a sampling procedure; 4. Differentiation of several types of sampling design.	
6.	Measurement and Scaling Techniques	Measurement in Research Measurement Scales Sources of Error in Measurement Assessing Data Provenance and Quality Tests of Sound Measurement Scaling and Meaning of Scaling Scale Classification Bases and Transformations	Questions, obstacles, and common misconceptions related to data measurements Example exercises: - Assess the data quality from a random Open Dataset Collection - Work with the data in order to obtain significant scale transformations (e.g.

	Lecture Topic	Lecture Detail	Practices (examples)
		Important Scaling Techniques Scale Construction Techniques	understand units of measure)
		Learning objectives: - Understand the right workflows for measuring and working with scales when looking at data - Understand the implications of working with Open Data in research methodologies Assess the data quality, provenance, granularity and transformations	
7.	Instruments to share Data in Research Methodologies	Why share research data? How to share your data? Journals and data sharing Research data centres	Example exercises: - SWOT Analysis of data sharing in research - Finding new research data centres
		Learning objectives: 1. Understanding the advantages of sharing research data 2. Learn about various ways to share research data 3. Identification of research data centres in accordance with the field of research	
8.	Preparation, Analysis and Processing of Data	Preparing data for analysis - Logging and Tracking Data - Data Screening - Selecting an Open Data source - Transforming data - Elements/Types of Analysis - Statistics in Research Data Analysis - Descriptive statistics - Measures of association - Inferential Statistics Interpreting data and drawing inferences - Processing Operations - Measures of Central Tendency, of Dispersion, of Asymmetry, of Relationship - Association in Case of Attributes	Questions, obstacles, and common misconceptions related to data preprocessing and analysis from Open Colletions Example exercises: - Select a random open data trace and interpret the descripritive stistics - Selecting a second dataset, interpret the correlation factors and conclude on causality Conduct statistical inference on either of the two dataset
		Learning objectives: - Be able to interpret correctly the descriptive statistics associated with Open Dataset - Be able to draw valid conclusions on the dataset analytics	

	Lecture Topic	Lecture Detail	Practices (examples)
9.	Data Interpretation and Hypothesis Testing	Meaning of Interpretation Technique of Interpretation Precaution in Interpretation Testing of Hypotheses-I Chi-square Test Testing of Hypotheses-II	Example exercises: - Randomly select any Open Dataset and formulate an analysis of statistical features - Formulate a hypothesis and make an analysis towards proving or dismantling it.
		Learning objectives: - Analyse an Open Data collection - Use the right paths to interpret the data and perform hypothesis testing	
10.	Multivariate Analysis Techniques based on Data Provenance	Definitions for Data Validation and Data Provenance; Application of Internal Validity; Application of External Validity.	Example exercises: - Questions regarding the definitions and the concepts. - Choose and apply the internal or/and external validity
		Learning objectives: 1. Understand the analysis techniques and who are they applied on data. 2. Become familiar with the Internal Validity and External Validity.	
11.	Ethical Considerations in OS Research	Concepts of ethics, morality and academic integrity; The ways of applying the ethical consideration in research	Example exercises: - Problems of the research methodology - Problems of academic integrity, morality and ethics
		Learning objectives: 1. Understand and apply the ethical considerations. 2. Understand the importance of the ethics and academic integrity impact on research	
12.	OA Disseminating Research Results and Distilling Principles of	Plan for disseminating process Set-up a project management and validate the methodology Report the research by publications	Example exercises: - Create a plan for dissemination. - Analyse the research methodology.

	Lecture Topic	Lecture Detail	Practices (examples)
	Research Design and Methodology		- Create a text for dissemination.
		Learning objectives: 1. Learn what major types of dissemination are available how the results are made visible to the audience. 2. Learn the advantages Research Design and Methodology.	

1.5. Information provided to Students about the module

This module specification is published by each Master organizer institution in its internal repository of MSC programmes. In order to ensure that this information is consistently presented, this is viewed as the primary source of information and is linked to in all information systems, e.g. website links and Moodle, which is the preferred virtual learning environment. This is also the source of information for teaching staff.

This specification, where appropriate, is also used as the primary source of information for printed material. In this case, until the module is approved in the context of the programme, information is indicative.

1.6. Teaching & Learning Strategy

For all lectures materials will be presented to student, either in the form of registered Lecture sessions, or Powerpoint and PDF study materials. Where needs, students will be re-directed to appropriate external resources for Individual Studies. All these content materials will be uploaded in Moodle so that all students have access to all materials and be able to apply a self-study pacing progress. In addition, Forums for discussion will be available on Moodle for a direct dialog between Lecturer and students.

The students will be encouraged to apply a group-based study methodology, where they can present various topics to their colleagues or directly apply the learning materials into given micro-projects.

The lectures will be a mix of presentation and practical analysis conducted by learners. Learners will be assigned specific tasks related to lecture content so that they can drill into concepts by applying some tools such as data repository access, create and storage a pre-print, and many others.

The Moodle classes will be delivered in a lecture theatre, if possible, with learners possibly bringing their own devices (BYOD). For remote access of students from outside the institution, an alternative platform like Microsoft Teams will be used to allow them to participate in all lectures.

Each week learners will attend two hours of. Lectures will be a mix of presentation and practical analysis conducted by learners with the assistance of the lecturer and teaching assistants. Learners will be assigned specific tasks related to lecture content so that they can drill into concepts by applying some tools such as R for Open Data research analysis.

Learners will discover concepts of OS research methodologies using an introducing the research cycle and activities which describe some of the core concepts, principles, actors, and practices in Open Science, and how these fit within a broader research ecosystem. Learners will have full access to necessary resources (outlined below) to complete each task. Lecturers will have a high level of competency in each of the methods and concepts used.

Learners are encouraged to attend and participate in all classes, as each session is intended to build upon previous classes in a practical, non-intimidating, informative, and enjoyable way. Throughout the module, the foundations of OS research workflows are applied to real life data to form learning of the fundamental ideas and the most used OS tools, services, practice during performing research activities.

1.7. Assessment Strategy

Assessment Type	Assessment Description	Outcome addressed	% of total	Assessment Date
Project	Develop a complex Open Science analysis or solution.	LO3, LO4	50%	Ongoing
Proctored Written Test	The test will assess learners' knowledge and understanding of concepts pertaining to each OS topic as described in Section 1.4.	LO1, LO2	50%	Week 14

Proctored Written Tests will vary from Open Book style tests to Closed Book.

1.8. Reading List & Other Resources

Recommended Book Reading

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Marczyk, G. R., DeMatteo, D., & Festinger, D. (2010). *Essentials of research design and methodology* (Vol. 2). John Wiley & Sons.

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (2018). *Citizen science: innovation in open science, society and policy* (p. 580). UCL Press.

Kitchin, R. (2021). *The Data Revolution: A critical analysis of big data, open data and data infrastructures*. Sage.

Supplementary Reading

Safarov, I., Meijer, A., & Grimmelikhuijsen, S. (2017). Utilization of open government data: A systematic literature review of types, conditions, effects and users. *Information Polity*, *22*(1), 1-24.

McKiernan, E. C., Bourne, P. E., Brown, C. T., Buck, S., Kenall, A., Lin, J., ... & Yarkoni, T. (2016). Point of view: How open science helps researchers succeed. *elife*, *5*, e16800.

Allen, C., & Mehler, D. M. (2019). Open science challenges, benefits and tips in early career and beyond. PLoS biology, 17(5), e3000246.

Easterbrook, S. M. (2014). Open code for open science?. *Nature Geoscience*, *7*(11), 779-781.

National Academies of Sciences, Engineering, and Medicine. (2018). Open science by design: Realizing a vision for 21st century research.

Irwin, A. (2021). Risk, science and public communication: Third-order thinking about scientific culture. In *Routledge handbook of public communication of science and technology* (pp. 147-162). Routledge.