README for the Learning Objectives Matrix on the Topic of Research Data Management (RDM)

V3

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Special thanks go to the Data Literacy Alliance (DALIA) project for taking the lead in organising the 2024 community event in Darmstadt and for its ongoing editorial work on the learning objectives matrix.

We are proud of this active and committed community and look forward to continued dialogue and collaboration.

In other words: You rock!

Thank you for your time and commitment!

Britta Petersen

for the editorial team and the sub-WG Training/ Further Education of the Research Data WG (DINI/nestor)

1 Introduction and objectives

This learning objectives matrix on the topic of research data management (RDM) pursues a generic approach with the aim of providing assistance for university lecturers, curriculum managers and people from the field of further training and education across subject and organisational boundaries: By comparing curricula from national and international training programmes, the aim is to provide recommendations on relevant subject areas and target group-specific learning objectives that contribute to the quality assurance of existing teaching and learning concepts as well as those currently under development. For this third version, all topics and learning objectives were reviewed in a community process, commented on, revised and standardised in terms of language. The accompanying material was revised and expanded, a glossary was developed and the first steps towards formalised provision of the learning objectives as Linked Open Data (LOD) were taken with a view to optimisation in line with the FAIR principles.

The RDM learning objectives matrix...

- creates transparency about expected teaching and learning content,
- can act as a 'central theme' in the learning process,
- serves to reflect on the learning process and to control it in a targeted manner, and
- provides operationalised learning objectives for exams, learning progress tests or self-assessments.

The RDM learning objectives matrix supports ...

- in the selection of relevant content,
- in the development and ongoing quality assurance of curricula and individual educational programmes and materials, and
- in the qualification of teachers.

The matrix proposes generic learning objectives on relevant RDM topics. These learning objectives are tailored to four target groups for which there are structured training and further education programmes: Bachelor (BA), Master (MA), Early Career Researcher (ECR) and Data Stewards (DS). The wording of the learning objectives for the different target groups supports the development and implementation of teaching and learning concepts that are orientated towards the needs of the target group. This promotes data and RDM skills.

The learning objectives matrix can serve as a working basis for an extended subject-specific design or other individual requirements (see section 6 on application scenarios and examples). The matrix can be expanded, is continuously improved and serves as a basis for discussion and work for the community. The editorial team is grateful for

feedback on improvements, extensions and best practices. Contact options are listed in chapter 9.

2 Target group

The RDM learning objectives matrix is aimed at all people in research or research-related areas who contribute to the development and expansion of knowledge and skills in dealing with research data. The overall aim of the matrix is to provide orientation in the subject area of RDM and to support the development of teaching/learning material and events as well as the integration of the subject area of RDM or individual aspects in courses, modules and curricula. In addition to the structured presentation of relevant topics, the matrix provides suggestions for operationalised learning objectives for different learning levels and learner target groups.

The target groups include staff at universities and research institutions whose job profile includes aspects of RDM or who have focused a large part of their job profile on them. The learning objectives matrix is aimed in particular at groups of people who organise information events and training courses on RDM or who support others in the design of courses or curricula as RDM multipliers. The matrix also provides support for lecturers in the departments who would like to integrate aspects of RDM into their courses.

3 Development process

3.1 Development of versions 1 and 2

Version 1 of the RDM learning objectives matrix (Petersen et al., 2022) was developed as part of the activities of the sub-WG Training / Further Education of the DINI/nestor Research Data WG (sub-WG Training/Further Education for short) with the aim of developing an orientation guide for RDM-relevant topics based on existing RDM-related training concepts and materials. Version 1 contains suggestions for learning objectives for different qualification levels to promote RDM competences, which were developed based on Engelhardt et al. (2022, Appendix E - Knowledge units and corresponding learning outcomes for the Bachelor's, Master's and PhD degree levels). An editorial team consisting of members of the sub-WG Training/Further Education collected and structured the topics and learning objectives listed in the German-language training

concepts and materials on the topic of RDM[1]. In several iterative steps, the editorial team and further experts, sorted and categorised topics and learning objectives and formulated the collected learning objectives in a results-oriented manner based on Bloom's (1956) and Anderson and Krathwohl's (2001) learning objective taxonomy. Version 1 of the learning objectives matrix was subsequently published in September 2022 (see also Fig. 1 for an overview of its history).

In version 2 (Petersen et al., 2023), which was published a few months after version 1, there were no significant changes to the content, but editorial adjustments. One valuable addition was the translation of the learning objectives matrix into English, which was carried out under the leadership of members of the National Research Data Infrastructure (NFDI) consortium NFDI4Health[2]. As part of the expansion to include English translations of the learning objectives, the layout of the learning objectives matrix was adapted.

The publications of the learning objectives matrix at Zenodo currently (as of 17 September 2025) have 15,106 views and 13,767 downloads. This shows the great demand and the strong interest of the RDM community in the learning objectives matrix. In particular, the content and its assignment to the target groups was discussed at various conferences and workshops. Since 2023, the learning objectives matrix has been discussed in the BMBF project DALIA[3] (Data Literacy Alliance) as a supporting tool for the knowledge base for 'FAIR data usage and supply'[4] as a federated knowledge base of the NFDI section Training and Education (EduTrain). Teaching/learning materials to support cultural change and skills development for the FAIR compliance and utilisation of research data are collected and indexed in the above-mentioned database. This was accompanied by a growing demand within the RDM community for additional networking, joint discussions and the further development of the learning objectives matrix as well as the publication of a new version three.

[1] Train-the-Trainer Konzept zum Thema Forschungsdatenmanagement (Biernacka et al., 2021), Zertifikatskurs Forschungsdatenmanagement NRW (Blümm et al., 2022; TH Köln, 2025; Modulhandbuch: Zentrum für Bibliotheks- und Informationswissenschaftliche Weiterbildung (ZBIW), 2024), Data Train Programm der U Bremen Research Alliance (Hörner et al., 2021; U Bremen Research Alliance, o. D.), data.RWTH an der RWTH Aachen University (Rheinisch-Westfälische Technischen Hochschule (RWTH) Aachen, 2024), eLBB4RDM an der CAU Kiel (Christian-Albrechts-Universität zu Kiel, 2022), Modul „Research Data Management" an der Universität Bielefeld (Universität Bielefeld, o. D.), FAIR Data Austria (Projektleitung TU Graz; Technische Universität Wien, o. D.)

[2] https://www.nfdi4health.de/en

[3] https://dalia.education/de

[4] DALIA Knowledge-Base: https://search.dalia.education/basic

3.2 Development of version 3

A community event on the learning objectives matrix was held in Darmstadt from January 31 to February 1, 2024 in order to gather feedback and suggestions for improvement from users in the RDM community and with the aim of creating a third version of the learning objectives matrix.[5] This was jointly conceived, organised and carried out by members of the sub-WG Training/Further Education, DALIA and the NFDI section EduTrain. The event was open to anyone interested in participating and free of charge. The event was announced via the DALIA website, the NFDI EduTrain section's Rocket.Chat Channel and mailing lists for RDM in Germany. A total of over 50 people participated in the event.

The event began with inputs on the general principles of formulating learning objectives as well as experience reports on the use of the learning objectives matrix from the community. In an extended discussion and work phase, the structure and content of the matrix were discussed and suggestions for revision were formulated.

The following aspects and objectives of the discussions were defined in advance and communicated to the participants:

- Review and update the content of the generic learning objectives matrix
- Review and update the listed subjects and topics
- Review and update the listed learning objectives
- Discussion on the allocation of learning objectives to qualification levels
- Discussion of table structure, forms of presentation, formalisation, storage and publication locations

Based on the design thinking method, the discussions took place in topic-related groups. The group formation was based on the six main subjects shown in the learning objectives matrix.[6] An additional seventh group discussed overarching topics, such as the structure of the LOM-table, codability of items and possible publication channels. Each discussion group was constantly guided through the discussion and work phases by a member of the event organisation team.

The discussions were documented in digital form in all groups during the event. Each group was provided with a digital version of the subject to be discussed and worked on, already prepared with comment columns, as a table in an online cloud drive in which the participants could comment and work collaboratively.

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[5] Short report in the DALIA newsletter: https://dalia.education/de/newsletter/20240302_no-2-maerz-2024#community-event-zur-lernzielmatrix-zum-forschungsdatenmanagement

[6] The detailed program of the event can be found here: https://liascript.github.io/course/?https://raw.githubusercontent.com/RDM4CAU/LZ4FDM/main/Ziele-und-Methode.md#1

All participants in the community event were invited to take part in the editorial work for the publication of the third version of the learning objectives matrix following the event. Until publication, regular editorial meetings were held to discuss general issues such as organisation and structure, the structure of the learning objectives, the consistent use of terms, the assignment of topics to subjects, the assignment of learning levels to the verbs used in the matrix and other issues. The specifications agreed in the overall editorial team were implemented in various subgroups and the content was intensively revised, considering the comments from the community event. In several iterations, the topic affiliation of the learning objectives as well as their completeness and redundancy were checked. This was done across teams and using OpenAI's ChatGPT.[7] The results of the work from the community event and the subsequent editorial work were released to the NFDI section EduTrain for comment before publication. The editorial team discussed the feedback received and incorporated it into the documents.

In the context of the work on the learning objectives matrix, the participants expressed a desire for a glossary to explain the terms used in the matrix. This glossary was compiled in constant consultation with the overall editorial team in a specially established working group. The glossary is attached to the learning objectives matrix in plain text form and in tabular form as a separate spreadsheet in the files LOM-RDM_V3_en.xlsx and LOM-RDM_V3_en.ods. An implementation of the glossary as a Simple Knowledge Organization System (SKOS) is provided via GitHub.[8] The development process of the glossary is described in detail in a glossary workshop report (Workshop_report-Glossary_LOM-RDM_V3_eng.pdf). A shorter version of the workshop report is also available in the README for the above-mentioned GitHub repository.

In addition to the working groups dealing with the learning objectives in the thematic subjects, further groups were formed focussing on the creation of accompanying materials and other matters (public relations, submission to conferences, etc.). An additional group also focussed intensively on how the matrix could be improved with regard to compliance with the FAIR principles. The results of this group's discussions are described in the chapter “'Towards Linked Data”'.

The entire process and its work steps (Figure 1) took place between February 2024 and March 2025.

[7] https://chatgpt.com/

[8] https://github.com/dini-ag-kim/fdm-lernziele

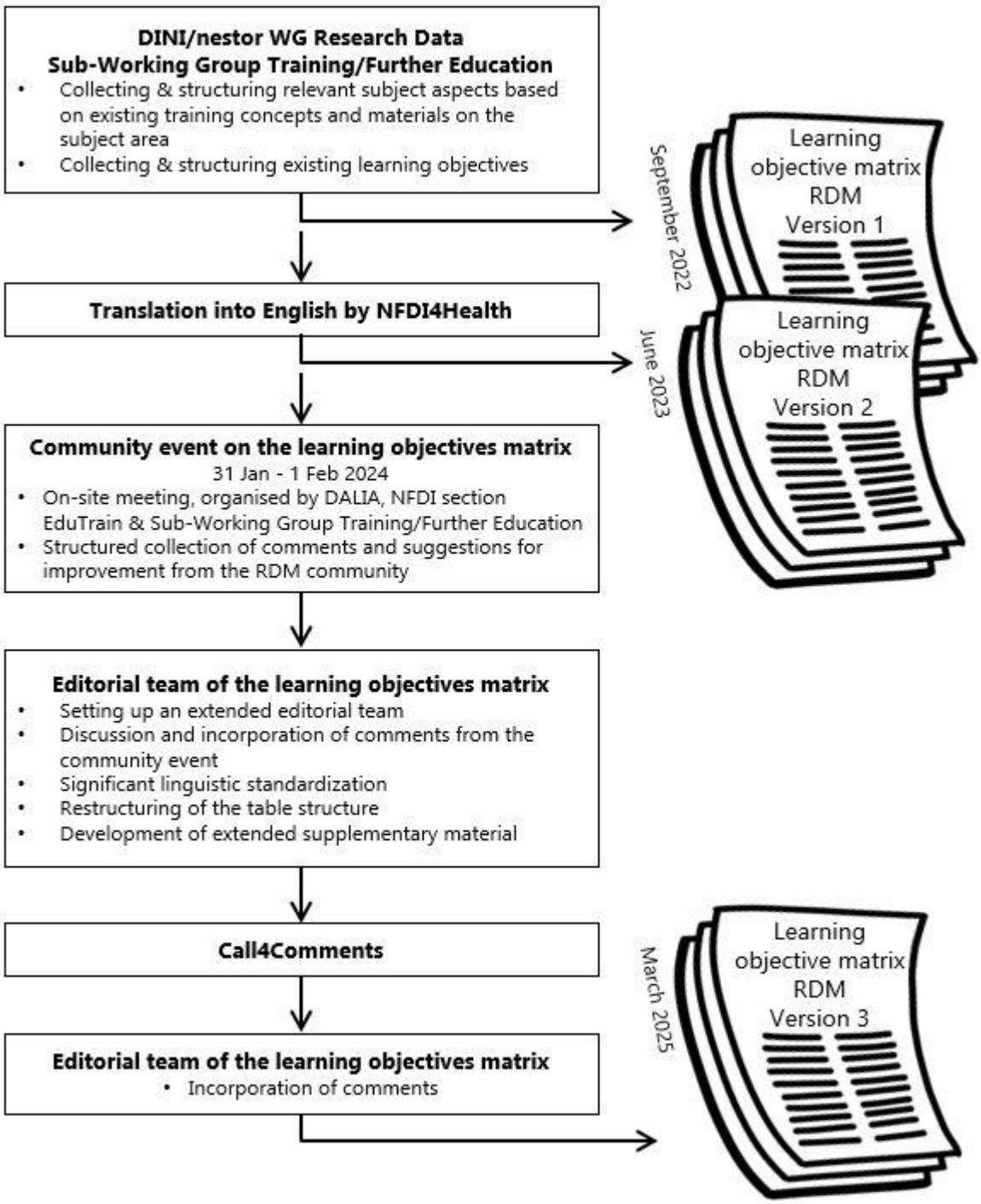

Figure 1: Overview of the history of the development of the learning objectives matrix for the RDM (Figure is available under the license 'Creative Commons Zero' V 1.0)

4 How-to-use

The learning objectives matrix on the topic of RDM is a structured tool designed to help trainers and learners identify relevant aspects of RDM and to teach and develop corresponding competences. The topics and learning objectives listed in the matrix also serve as a framework, harmonised with the community.

As the RDM learning objectives matrix takes a generic approach, users must individually select and, if necessary, adapt topics and learning objectives for their own use case. The learning objectives in the matrix are no substitute for a curriculum developed for a specific subject area or group of people, nor for specific schedules for individual RDM events. The learning objectives listed here help to identify, select, compile and prioritise relevant aspects of the RDM as well as suitable learning objectives to enable appropriate teaching for the respective target group(s).

The topics and learning objectives should not be 'worked through' one after the other in the order shown in the matrix. The selection, compilation and sequencing of topics and learning objectives for a curriculum or event planning with specific learning activities and assessment scenarios must be selected individually depending on the target group and subject-specific requirements of a specific use case. Depending on the didactic scenario, a different composition and sequence of topics and learning objectives is always possible for planned educational programmes. Therefore, it is always necessary to check which thematic aspects and which of the learning objectives listed there may be suitable for your own subject-specific requirements, the specific use case and the target group(s).

Users should not only select and sort the topics and learning objectives individually but also adapt and refine the learning objectives according to their subject or application specifics, e.g. by adding subject-specific conditions. This is the only way to ensure that the learning objectives are optimally tailored to the specific requirements and circumstances of a curriculum or to individual teaching or further education events. General information and assistance for formulating learning objectives and for customising existing learning objectives can be found in the following section.

4.1 Formulation of learning objectives

The formulation of learning objectives is an important and central component of planning teaching/learning scenarios, as they serve as a guideline for the entire didactic design. Clearly formulated learning objectives allow courses to focus on the desired learning outcomes and effectively manage learners' learning processes. They ensure that both teachers and learners know what will be achieved by the end of the course.

They provide a basis for the selection of suitable teaching methods and forms of assessment.

Learning objectives have various advantages for the design of teaching:

For those responsible for curricula:

Learning objectives...

- define which knowledge and skills and which subject-specific understanding are to be achieved in a degree programme or module and thus form a qualification framework.
- enable classification in structural guidelines, e.g. of the Standing Conference of the Ministers of Education and Cultural Affairs of the German federal states (Kultusministerkonferenz, KMK), the Accreditation Council, the requirements of the national and European Qualifications Framework and, if applicable, other academic guidelines.
- enable the comparison of educational activities.
- are a requirement for the targeted preparation of learning programmes.

For trainers:

Learning objectives...

- help with the planning of learning activities and act as a common thread for lesson planning.
- help with the creation, concretisation and structuring of learning or teaching content.
- facilitate learning success monitoring by describing clearly observable, 'measurable' behaviours and criteria.
- can increase learning efficiency.

For learners:

Learning objectives...

- help to get an overview of the content and requirements covered in a learning unit.
- provide orientation in assessing one's own learning progress can increase the efficiency of learning.
- can support self-directed learning.

4.2 Operationalisation of learning objectives

When formulating learning objectives, it is generally important to ensure that the achievement of the objective is defined as clearly as possible. It is important to formulate verifiable learning objectives that are as operationalised as possible (see

below), by means of which the learning success can be systematically ‘measured’ and evaluated.

It is important to use clear formulations and verbs that enable behavioural observation (and thus measurability) (see Table 1).

Table 1: Example of unambiguous and ambiguous formulations of learning objectives

Unambiguous formulation	Ambiguous formulation
Name, explain, apply, analyse, assess, design	know, understand, know, believe, be familiar with, be interested in, be informed
Example: Learners can explain the FAIR principles.	Example: Learners are familiar with the FAIR principles.

Operationalised learning objectives consist of a content component and an action component. The content component provides information on which specific content knowledge or skills are to be acquired. The action component describes the behaviours that are used to ‘measure’ whether learners have achieved the learning objective. A learning objective can only be checked, or "measured," if it describes an observable behaviour.

A learning objective is considered operationalised if ...

- actual observable behaviours of the learners are described (e.g. "learners can name the criteria" instead of "learners know something about the criteria") and thus
- there is verifiability of goal achievement.

Learning objectives can be formulated in varying degrees of detail. The more precise the formulation, the more specific the conditions and assessment criteria for achieving the objectives. The precise formulation of the learning objectives presented here must be carried out by the subsequent users. For example, the measurability of the achievement of the learning objective ‘Learners are able to explain the FAIR principles.’ (LO ID: 01_007_0119) can be concretised in various ways by adding conditions. For example, ‘Learners can explain the FAIR principles in writing in 3-4 sentences’ or ‘Learners can explain the FAIR principles in the form of a short 5-minute presentation using a data set of their choice’.

4.3 Structure of the learning objectives in the matrix

The learning objectives matrix for RDM deliberately provides rough learning objectives whose sentence structure always follows the following scheme:

[learners are able to] [action component/verb] [content component]

In order to ensure standardised creation and future processing, the individual parts of the learning objectives in the table are distributed across columns F, G and H (see Table 2 for the three columns).

Table 2: Example of the formulation of learning objectives and the application of the syntactic schema

Learning objective start	LO verb	Learning objective content
Learners are able to	explain	the characteristics of open and restrictive licences.

In column R, under the column heading ‘Learning objective complete’, each learning objective is also provided in full for easy copying out. See also the section "Structure of the matrix".

By adding conditions under which observable behaviour should take place (e.g. under supervision, independently, in writing, in group work, within a time frame, relevant for subject X), the operationalizable learning objectives of the matrix can be refined and tailored to your own didactic scenario.

4.4 Bloom's learning objectives taxonomy

In the learning objectives matrix, a learning level is indicated for each learning objective based on Bloom's taxonomy (1956 or the extended version by Anderson & Krathwohl, 2001) in column I (Bloom's level). Bloom's taxonomy divides learning objectives into different cognitive levels, ranging from simple memorisation and knowledge recall to more complex processes such as analysis, synthesis and evaluation. The indication of the learning level in the matrix is intended to support the structuring of learning processes in individual didactic scenarios and to ensure that learning objectives are taught in a meaningful sequence and with an appropriate level of difficulty. The assignment to a level is based on the action component, i.e. on the verb used for a learning objective. In the interests of linguistic harmonisation, the learning objectives matrix uses a very limited selection of a few verbs, each of which is assigned to Bloom's levels. The assignment is shown in Figure 2.

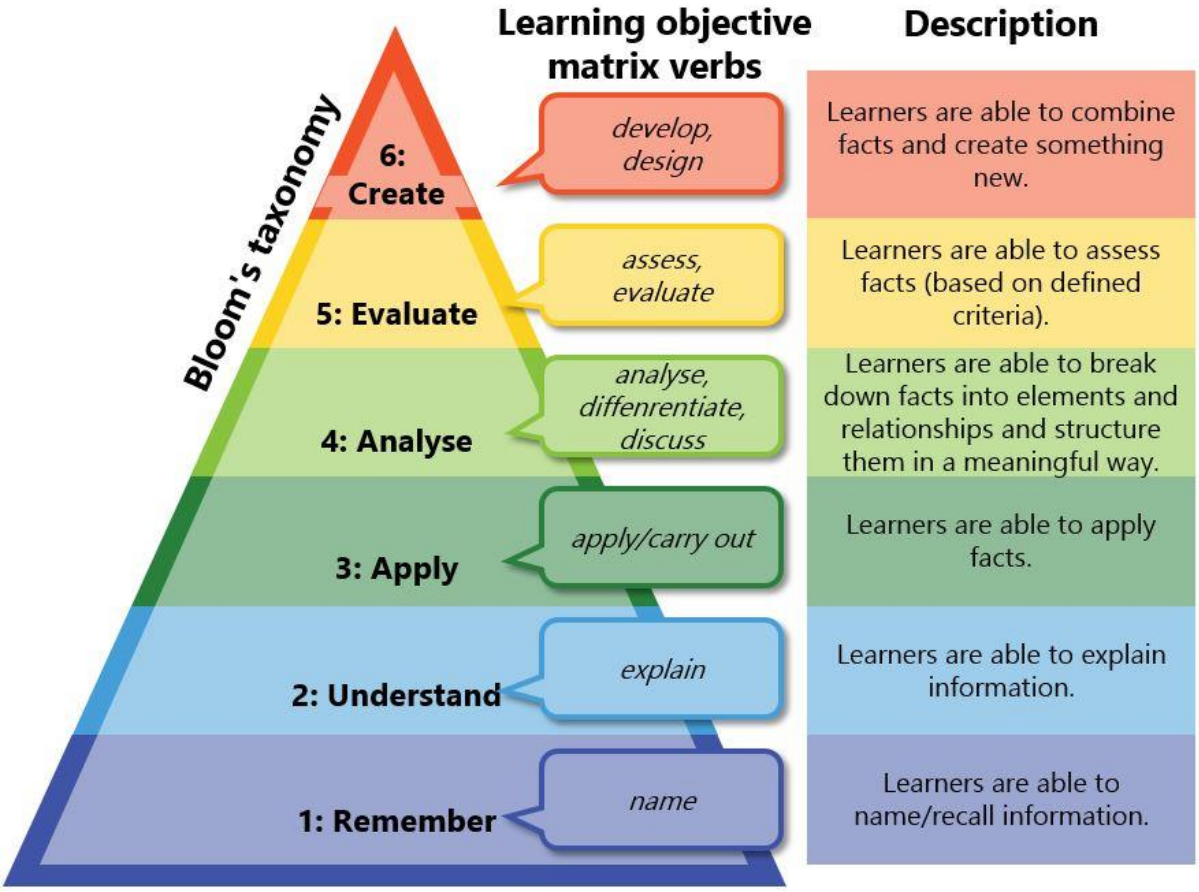

Figure 2: Learning levels of the learning objective taxonomy according to Bloom as well as selection and assignment of the verbs used for the learning objectives matrix (illustration is licensed under 'Creative Commons Zero' V 1.0 https://creativecommons.org/publicdomain/zero/1.0/deed.de)

Additionally, user can choose from numerous alternative verbs for customised learning objectives. There are various verb lists[9] that can serve as a source of inspiration and orientation. Subject-specific differences in the assignment of a verb to a taxonomy level or even the double assignment of a verb to different levels are possible. It should be noted that the taxonomy levels are not synonymous with assignment to a specific target group of learners.

[9] e.g. https://static.uni-graz.at/fileadmin/lehr-studienservices/Curriculaentwicklung/Lernergebnisse/Verbentabelle_Lernergebnisse.pdf; https://lehreladen.rub.de/wp-content/uploads/2022/07/verbliste-sammlung-deutsch.pdf

4.5 Knowledge dimensions

The learning objectives matrix systematically displays four knowledge dimensions for a specific learning objective[10]. The knowledge dimensions "factual knowledge (FK), conceptual knowledge (CK), procedural knowledge (PK), and metacognitive knowledge (MK)" are each assigned dichotomously to the respective learning objectives in document LOM-RDM_V3_eng.xlsx, worksheet "Learning objectives" columns N-Q. They indicate which knowledge dimensions are addressed by the respective learning objective. In this context, factual knowledge refers to basic facts including knowledge of terminology and knowledge on details and specific elements; conceptual knowledge concerns the interrelationships between elements within a large structure that enable them to function together such as classifications and categories, principles and generalisations as well as theories, models, and structures; procedural knowledge refers to knowledge on how to do something which includes subject-specific skills and algorithms, techniques and methods as well as criteria for determining when to use appropriate procedures; metacognitive knowledge is the awareness of one's own cognition concerning strategic knowledge, knowledge about cognitive tasks as well as self-knowledge. The assignment of a knowledge dimension to a learning objective is indicated by an 'x' in the corresponding cell. A learning objective can address several knowledge dimensions. The information on the knowledge dimensions (Table 3) is based on the action component, i.e. the verbs used in each case.

For users of the learning objectives matrix, this information is intended to provide guidance on how learning objectives can be compiled and sequenced in order to address different knowledge dimensions within the framework of a didactic scenario. It should be noted that by adding conditions to an existing learning objective or by changing the action component (verb) of a learning objective, the knowledge dimensions addressed by the learning objective may be expanded or changed.

[10] Translators' note: in the original German version, instead of knowledge dimensions, a categorisation according to "areas of competence" (Kompetenzbereiche) was used, these being "Sachkompetenz" (usually translated as "professional competence"), "Methodenkompetenz" (i.e. "methodological competence"), "Selbstkompetenz" and "Sozialkompetenz", a categorisation which is anchored in Germany through the German Qualification Framework for Life-Long Learning ("Deutscher Qualifikationsrahmen für lebenslanges Lernen"). As this categorisation is not used in the context of Bloom's taxonomy of learning objectives outside Germany, we decided for the translation to adopt the knowledge dimensions categories originally proposed by Anderson et al. (2001) in the revised version of the taxonomy. This ensures the international applicability of the LOM. This also affected the assignment of the knowledge dimensions (formerly areas of competence in the original) in accordance with the verbs used since both categorisations do not completely match conceptually which does not allow retaining the original assignment.

Table 3: Knowledge dimensions and indicative verbs

Knowledge dimensions	Action component [verbs]	Explanation
Factual knowledge	name	In order to be able to name something factual knowledge is required.
Conceptual knowledge	explain	In order to be able to explain something, factual and conceptual knowledge is required.
Procedural knowledge	apply, analyse, differentiate, associate, carry out, implement, choose	In order to apply, analyse, differentiate, associate, carry out, implement, choose something, both factual and conceptual knowledge but also procedural knowledge is necessary.
Metacognitive knowledge	discuss, assess, evaluate, design, develop or justify	Discussing, assessing, evaluating, designing, developing, justifying require not only factual, conceptual and procedural knowledge but also metacognitive knowledge.

4.6 Customisation of learning objectives

As already described, the learning objectives in the matrix always follow the same structure:

[learners are able to] [action component/verb] [content component],

e.g.: [learners are able to] [name] [the FAIR principles].

The learning objectives listed are linguistically concise, do not contain any (subject) specific conditions and use a limited selection of verbs for the action component. Although the learning objectives can be used directly, it makes sense to refine them for your own purposes.

The content components of the existing learning objectives can be supplemented with (subject) specific conditions as well as conditions relating to forms of learning or examination. Examples follow below.

The action component (verb) of a learning objective can and may also be changed and adapted. The learning objectives matrix does not use the full range of available verbs

for the action components, so users of the matrix may have to add these themselves. In addition, there are numerous other alternatives for verbs specifying action components. To customise the action component, we recommend using suggestion lists with verbs along Bloom's taxonomy.[11]

4.7 Examples of customisation of learning objectives

Table 4 provides several examples of how learning objectives can be customised. In each case, the basis is a learning objective from the matrix (with reference to the position in the matrix using the learning objective ID) in the left-hand column. Various possible customisations can be found in the right-hand column.

Table 4: Examples of customised learning objectives

Learning objective:	**possible customisation(s):**
Learners are able to explain functions and responsibilities of people in RDM. (LO-ID 01_003_0033)	Learners are able to explain the functions and responsibilities of **conservators and restorers**. (Hastik & Schwenk, 2025) Learners are able to explain the functions and responsibilities of people in RDM **using a diagram created in group work**. Learners are able to *discuss* the functions and responsibilities of people in RDM, **first in small groups and then as a whole group**.
Learners are able to explain stages of the research data life cycle. (LO-ID 01_005_0081)	Learners are able to explain the stages of the research data life cycle **in social science research**. Learners are able to *describe* the stages of the research data life cycle **in relation to a self-selected experiment of the internship**. Learners are able to explain in writing the stages of the research data life cycle **in relation to the creation of a digital edition**.
Learners are able to carry out a submission process to	Learners are able to carry out the submission process to **the Pangaea repository** independently.

[11] e.g. https://static.uni-graz.at/fileadmin/lehr-studienservices/Curriculaentwicklung/Lernergebnisse/Verbentabelle_Lernergebnisse.pdf; https://lehreladen.rub.de/wp-content/uploads/2022/07/verbliste-sammlung-deutsch.pdf

Learning objective:	**possible customisation(s):**
a repository independently. (LO-ID 04_004_0877)	Learners are able to carry out the submission process for a **dataset prepared in the practical course in the institutional** repository independently.
Learners are able to develop file naming conventions independently. (LO-ID 02_006_0329)	Learners are able to develop a file naming convention **for the measured data generated in the semester project** independently. Learners are able to develop a file naming convention **for the data shared in the project**, **which is documented in the form of a README collaboratively**. (Link to LO-ID: 02_006_0331: 'Learners are able to develop documentation for file naming conventions independently.')

It should be noted that the addition of conditions or the use of a different verb for the action component may also change the information given in the matrix on the learning level according to Bloom. In addition, the information on the areas of competence addressed by the learning objective may also change. This can be shown using the following example:

Original learning objective: 'Learners are able to apply versioning methods.' (LO-ID-02_008_0362).

This learning objective refers to the ability of learners to use versioning methods correctly. It addresses professional competence and methodological competence, as learners must understand and implement both the technical basis (versioning methods) and the application methods.

If the learning objective is refined with the condition 'collaborative', it reads: 'Learners are able to use versioning methods collaboratively.'

This adaptation extends the original objective to include the aspect of collaboration between learners. This also addresses social skills, as learners now not only need the technical skills, but must also be able to communicate effectively in a team and use the versioning methods together.

The verb 'apply' is assigned to learning level 3 in the learning objectives matrix. By changing the action component of the original learning objective by replacing the verb 'apply' with the verb 'discuss', the learning objective reads: "Learners are able to discuss versioning methods". This adaptation ensures that the learning objective would now be assigned learning level 4. In addition, the areas of competence addressed are also

expanded here, as discussing requires not only professional and methodological competence, but also a certain level of social competence.

5 Table Format – Components of the Learning Objectives Matrix

The learning objectives matrix for RDM is available in tabular form in both .xlsx and .ods file formats. Additionally, the "Learning Objectives" worksheet is also provided in .csv format. The available .xlsx and .ods files each contain five worksheets, which are explained in detail below:

5.1 Worksheet *How-to-use*

The How-to-use worksheet provides a brief guide on how to use the matrix, summarising the key aspects covered in this chapter.

5.2 Worksheet *Index*

The Index worksheet offers an overview of the main topic areas in RDM. To improve clarity, the topics are grouped into subjects and visually separated using different background colours. Neither the clustering, nor the order, nor the colour coding reflects any ranking or weighting of the listed topics. These elements are intended solely to enhance readability and comprehension.

5.3 Worksheet *Learning Objectives*

The Learning Objectives worksheet (Table 5) contains all subjects, the individual topics within them, and the corresponding learning objectives. The table contents of the Learning objectives worksheet can be filtered in standard spreadsheet software via the header.

Table 5: Structure of the *learning objectives* worksheet

Column	Header	Column content
A	LO-ID	ID of the learning objective [subject]_[topic]_[learning objective] in form of [00]_[000]_[0000]
B	Subject	Name of the subject
C	S-ID	ID of the subject [subject] in form of [00]
D	Topic	Name of the topic
E	T-ID	ID of the topic [subject-ID]_[topic] in form of [00]_[000]
F	Learning objective start	Start learning objective (“Learners are able to”)
G	Learning objective verb	Action component of the learning objective (verb)
H	Learning objectives content	Content component of the learning objective
I	Level (Bloom)	levels of objectives according to Bloom
J-M	BA, MA, ECR, DS	Appropriateness for target groups of learners (BA = Bachelor's students, MA = Master's students, ECR = Early Career Researcher, DS = Data Steward) each dichotomously with [x] for applicable
N-Q	FK, CK, PK, MK	Knowledge dimensions addressed by the learning objective. (FK = factual knowledge, CK = conceptual knowledge, PK = procedural knowledge, MK = metacognitive knowledge) each dichotomously with [x] for applicable
R	Complete learning objective	Result of the concatenation of columns F, G and H

Learning objectives (columns F-H)

A learning objective is always made up of the three columns F (learning objective start), G (learning objective verb) and H (learning objective content). The division of the learning objectives into several columns specifies their linguistic structure and enable

their harmonious formulation. The learning objectives are arranged in random order for each subject. The composition and sequence in which learning objectives are developed in a didactic scenario must be defined for the individual use case.

Columns J-M: Appropriateness for target groups of learners

Columns J-M represent possible target groups of learners. The learning objectives matrix distinguishes between four learner target groups:

BA = Bachelor's students

MA = Master's students

ECR = Early Career Researcher (doctoral students, postdocs)

DS = Data Steward

The suitability of a learning objective for one of the target groups is indicated by an x in the corresponding cell. The information on the suitability of a learning objective for a specific target group is an assessment by the editorial team of the learning objectives matrix. The suitability of a learning objective for a specific group of learners should be checked and adapted individually for your own purpose (see also chapter 4.6 Customisation of learning objectives).

Columns N-Q: Knowledge dimensions addressed by the learning objective

The knowledge dimension factual knowledge (FK), conceptual knowledge (CK), procedural knowledge (PK) and metacognitive knowledge (MK) are assigned to the respective learning objectives in columns N-Q. The knowledge dimensions addressed are indicated for each learning objective. The assignment of a knowledge dimension to a learning objective is indicated by an x in the corresponding cell.

Column R: Complete learning objectives

In column R ('complete learning objective'), the components of the learning objectives from columns F, G and H are merged.

5.4 Worksheet *Glossary*

The glossary worksheet (Table 6) includes the terms an their definitions from the glossary, as well as the references. The structure of the table is based on SKOS (Simple Knowledge Organisation System)[12], a standard for the representation of controlled vocabularies for machine-readable processing. Terms are recorded as concepts (skos:Concept) and provided with standardised designations and relations. Each glossary entry includes a unique ID, the terms described in German (skos:prefLabel@de)

[12] https://www.w3.org/2004/02/skos/

and English (skos:prefLabel@en) as well as a context-related definition (skos:editorialNote). In addition, a distinction is made between direct (skos:exactMatch) and indirect (skos:closeMatch) references in order to make the origin of the term usage transparent.

Table 6: Structure of the glossary worksheet

Column	Column labelling	Column content
A	opaque ID for glossary concept (skos:Concept)	opaque ID for glossary concept
B	English term (skos:prefLabel@en)	English term
C	Term explanation (glossary entry) (skos:scopeNote)	Explanations of terms in the context of use of the learning objectives matrix (glossary entry)
D	citation to indirect quotation (skos:closeMatch)	citation to indirect quotation
E	reference to indirect quotation (skos:editorialNote)	reference to indirect quotation
F	citation to indirect quotation (skos:closeMatch)	citation to indirect quotation
G	reference to indirect quotation (skos:editorialNote)	reference to indirect quotation
H	citation to direct quotation (skos:exactMatch)	citation to direct quotation
I	Reference to direct quotation (skos:editorialNote)	Reference to direct quotation

5.5 Worksheet *Change Log*

The 'Change Log' worksheet documents, controls and provides transparency of changes made, listing them in short form. It is implemented with the current, 3rd version of the learning objectives matrix and will be maintained for further versions.

6 Application scenarios and examples

The learning objectives matrix has already established itself as a relevant tool within the RDM landscape through its first two versions and is increasingly being adopted by the community. To illustrate potential use cases of the matrix, theoretical application scenarios are outlined first. This is followed by an introduction to practical examples in which the matrix has already been used. The collected application examples are provided in a separate table document in the appendix.

6.1 Application Scenarios

The following provides an overview of prototypical application scenarios in which the learning objectives matrix can be used, each accompanied by a brief description of the respective scenario.

Discipline-specific Adaptation of the Learning Objectives Matrix

- As a teaching professional, I would like to reuse the generic learning objectives from the matrix to identify RDM-related topics relevant to my courses. Based on this, I formulate discipline-specific learning objectives and design my courses accordingly.
- As a representative of an NFDI consortium, I would like to use the generic learning objectives matrix to create a discipline-specific adaptation. This serves as a starting point for designing our training content and formats.

Development of Teaching or Training Activities

- As a data steward, I would like to organise a workshop on file naming and folder structure for the research group I support. I refer to the relevant learning objectives tailored for early career researchers.
- As the organising team of a part-time certificate course in RDM, we want to use the learning objectives matrix to identify content and learning goals for the various course modules.

Self-Study and Skills Development

- As a researcher, I would like to use the learning objectives matrix to systematically improve my own skills in RDM.

Creation and Quality Assurance of Teaching Materials

- As a teaching professional, I would like to use the learning objectives matrix to develop teaching materials on RDM topics. I use the topics and learning objectives as a guide to ensure that students acquire the relevant competences.

- As a teaching professional, I would like to reuse existing teaching/learning materials on RDM. The learning objectives matrix helps me assess the content quality of the materials.
- As a teaching professional, I would like to publish my self-developed teaching/learning materials as open educational resources (OER). To support findability and quality assessment, I indicate the learning objectives addressed in my materials.

Curriculum Development in Higher Education

- As the coordinator of a degree programme, I would like to use the learning objectives matrix to systematically integrate RDM competences into a Master's curriculum in preparation for reaccreditation. This helps ensure that students acquire the skills they need for careers in research and industry.

PhD Programmes

- As the programme manager of my university's doctoral college, I would like to design a summer school on data reuse and research data publication. The learning objectives matrix supports me in selecting appropriate learning goals and structuring the event.

6.2 Practical Examples

In addition to the outlined application scenarios, the learning objectives matrix has already been used in a variety of practical contexts. The examples listed in the supplementary materials table Practical_examples_LOM-RDM_V3_eng.xlsx include, among others, discipline-specific adaptations by NFDI consortia for use in consultations, teaching/learning materials, or the development of assessment rubrics for examinations based on the learning objectives.

Further practical examples have been compiled and presented in a clearly structured table format to serve as inspiration for others. In addition to the detailed list in the appendix of the learning objectives matrix, these and other adaptations are also summarised on the matrix's wiki page at Forschungsdaten.org[13]. Additional examples and adaptations can be added directly by users or reported to the editorial team of the learning objectives matrix.

[13] https://www.forschungsdaten.org/index.php/Lernzielmatrix#Konkrete_Anwendungen_/_Adaptionen

7 Towards Linked Data

The FAIR principles (FORCE11, 2021; Wilkinson et al., 2016) play a central role in RDM and define requirements that research data should meet to ensure reusability. This idea of sustainability is also a core aspect of the learning objectives matrix. In addition to updating and revising the content of the learning objectives, targeted efforts have been made to enhance the interoperability and machine-readability of the matrix, aligning it more closely with the FAIR principles. Semantic enrichment, for example, aims to optimise automated analysis and the linking of learning objectives with digital teaching and learning materials. Integration into portals and aggregators for Open Educational Resources (OER), such as DALIA, is also being considered.

This chapter outlines proposals for how the learning objectives matrix can be improved in line with the FAIR principles through the use of structured and semantically enriched formats. A structured overview of subjects, topics, learning objectives, learning levels (Bloom) and knowledge dimensions - aligned with relevant target groups - serves as the basis for semantic enrichment. The aim is to make the matrix machine-readable as a Linked Open Data (LOD) model, thereby enabling sustainable, computer-based reuse. Previous versions of the matrix (Petersen et al., 2022, 2023) were already identifiable and accessible via Digital Object Identifiers (DOIs). They were provided in tabular format across various file types, including CSV, and were accompanied by a README file and clearly defined licensing terms—partially aligning them with the FAIR principles.

An initial data-wrangling approach (Zänkert, n.d.) demonstrated the potential for computer-based reuse of the matrix (version 2), but also revealed data quality issues, such as missing or incomplete values. It became evident that the tabular structure was not ideal for standardised, model-based, and interconnected representation. However, visualisations[14] generated as part of this effort highlighted the added value of extended analytical and presentation options: they improved the understanding of the matrix and allowed for targeted adjustments and content development. These insights heightened awareness of the need to optimise the matrix, particularly in terms of interoperability and machine-readable structures.

Structural, formal, and technological improvements were explicitly discussed from the outset - both during the community event on the learning objectives matrix in Darmstadt and in subsequent editorial work. Concrete requirements were explored using examples such as reuse in DALIA's advanced search and other application cases. Overall, it became clear that the tabular format of the matrix does not sufficiently meet the FAIR principles, particularly in terms of interoperability, machine usability, and

[14] https://zaesa.github.io/RDM-Lernzielmatrix/

precise citability. The following key challenges highlight the need for semantic modelling to improve the matrix's interoperability, referencing, and reusability:

1. **Static data presentation:** While tabular formats are structured, they offer limited interactivity and connectivity.
2. **Lack of persistent identifiers:** The matrix is available via Zenodo in XLSX, ODS and CSV formats with metadata, but individual elements (e.g., learning objectives or topics) do not have persistent identifiers such as DOIs or Uniform Resource Identifiers (URIs), which complicates fine-grained referencing in LOD environments and metadata services.
3. **Limited machine accessibility:** Although CSV is an open and widely used format, offering the data through a standardised Application Programming Interface (API) or web interface would greatly improve machine querying and integration into LOD systems.
4. **Long-term access of individual components:** While Zenodo provides some level of long-term access through DOI referencing, there is no infrastructure to ensure persistent linking of individual matrix elements.
5. **Lack of semantic structure:** The tabular format includes neither standardised relationships nor links to existing LOD vocabularies such as the Simple Knowledge Organization System (SKOS) or Dublin Core. Moreover, there is no clear namespace or machine-readable column descriptions, which limits interoperability.
6. **Unclear workflows for versioning and multilingualism:** Currently, no clearly defined processes exist for managing versions, changes, or multilingual availability of the matrix.

There are several alternatives to a purely tabular presentation of the learning objectives matrix in XLSX, ODS or CSV format, which enable better compliance with the FAIR principles and address the challenges mentioned above. Semantic web technologies are particularly suitable for greater interoperability and more precise referencing of the individual components of the matrix. These ensure that terms and their relationships are formally defined, systematically described and presented in a machine-readable form - for example, using semantic modelling languages such as SKOS or Web Ontology Language (OWL). The use of ontologies and standardised vocabularies adds a deeper semantic layer that simplifies interpretation and linking with other data sources. For this purpose, the components of the learning objectives matrix must be defined as concepts and their relationships must be formally described. As part of the semantic indexing, key concepts have already been identified, relevant metadata profiles reviewed, and initial ontology drafts created.

An obvious approach is to model the learning objectives matrix using SKOS. SKOS is a W3C standard for representing thesauri, ontologies, and classification systems, and it is

fully compatible with LOD and the FAIR principles. SKOS is particularly well-suited for the hierarchical organisation of learning objectives, as it allows Linked Data usage and provides a clear, transparent structure. Implementing the learning objectives matrix in SKOS can significantly enhance interoperability by:

- **URIs are assigned to individual concepts**: Each entity in the matrix (e.g., learning objectives, subjects, topics) receives a unique, persistent URI.
- **LOD integration is enabled:** SKOS can be linked to existing ontologies such as Dublin Core, Wikidata, or other educational standards.
- **Machine-readability is ensured:** The structure is optimised for Resource Description Framework (RDF) databases and SPARQL Protocol and RDF Query Language (SPARQL) queries.
- **A structured and standardised semantic is used:** Hierarchical and associative relationships are clearly defined; multilingual labelling is supported, along with clear provenance information and the ability to reference individual components.

In order to establish the learning objectives matrix as a resource in the sense of LOD, several open issues still need to be addressed: Currently, there is no "single point of truth", meaning that a central, reliable source for all relevant data and information is lacking. In addition, clear workflow for the coordination, development, and maintenance of a model must be defined. Technical aspects such as the allocation of identifiers, the namespace, and publication options also need to be precisely specified. A SKOS version of the learning objectives matrix is currently in preparation. To ensure that this development becomes a true community-driven product, all interested parties are warmly invited to contribute and participate.

8 Summary and Outlook

Between 2024 and 2025, numerous steps were taken to further develop and establish the learning objectives matrix. In regular editorial meetings, the content structure was refined and revised. In addition, accompanying materials were created to facilitate the use of the matrix. The introduction of a glossary - also published in SKOS format as LOD - along with the listing of application scenarios and examples, has increased the matrix's user-friendliness, reusability, and sustainability. Moreover, the matrix has been expanded through subject-specific discussions (e.g., within the framework of the NFDI) and supplemented with additional overviews. Further adaptations of the learning objectives matrix will follow.

The visibility of the matrix has been enhanced by the creation of a dedicated wiki page at Forschungsdaten.org[15]. For 2025, abstracts have been submitted to various conferences to present the latest developments and raise awareness of the matrix within the community. In addition, members of the editorial team actively promote the new version through their involvement in different networks, organisations, and events.

Initial ideas for expanding the content of a future version 4 of the matrix already exist. Feedback from the community, collected between December 2024 and January 2025 via a Call for Comments, highlighted the following aspects:

- **Integration of "Critical Thinking" as a Core Topic**
  The ability to critically reflect on research data practices should be embedded in the matrix. Planned additions include topics such as methodological transparency and conscious engagement with uncertainty and bias.
- **Expansion to Include the Crosscutting Topic "Resources and Sustainability"**
  The matrix should address sustainable use of technical, human, and ecological resources. Possible aspects include energy-efficient data storage and processing, and sustainable infrastructure solutions.

These and other enhancements can be discussed with the community at conferences and similar forums, in order to tailor them to actual needs and incorporate them into future versions of the matrix. A successful development process for the learning objectives matrix is inextricably linked to an active community. Ongoing dialogue within the RDM community has helped identify needs, explore new topics, and develop the matrix in a targeted and user-oriented way.

Key to this process are transparent, open communication about content and progress, opportunities for active participation, and collaboration with experts. Only through a dedicated, cross-disciplinary community that shares its knowledge can the learning objectives matrix continue to evolve as a dynamic, practice-oriented, and forward-looking tool.

9 Contact

News about the Learning Objectives Matrix is shared via the mailing list "Umgang mit Forschungsdaten" (https://www.listserv.dfn.de/sympa/info/forschungsdaten), the NFDI Section EduTrain mailing list, and the Learning Objectives Matrix page at Forschungsdaten.org (https://www.forschungsdaten.org/index.php/Lernzielmatrix).

[15] https://www.forschungsdaten.org/index.php/Lernzielmatrix

If you have questions, comments, or would like to share your own use cases of the matrix to be featured on Forschungsdaten.org, the editorial team can be contacted via the sub-WG Training/Further Education of the DINI/nestor WG Research Data mailing list: uag-fdm-schulung@dini.de. Alternatively, use cases can be submitted directly on Forschungsdaten.org after creating an account, helping to enhance the matrix's visibility. Comments and contributions via GitHub (https://github.com/dini-ag-kim/fdm-lernziele) are also very welcome.

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