Activities and Challenges in Developing Discipline-Specific Data Management Plan Templates: From Vertical to Horizontal Integration of RDM Practices

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Abstract

To provide tailored guidance on research data management, discipline-specific data management plan (DMP) templates are core. Different stakeholders are pursuing the development of such discipline-specific DMP templates in different ways. In this paper, we present three such approaches. First, we introduce the concept of domain data protocols, describing the work of the project *Domain Data Protocols for Empirical Educational Research* (in Germany). Members of this project develop tailored guidance on research data management (RDM) vertically, i.e., within the educational research discipline. Second, we present the approach of the *Research Data Alliance Working Group* on *Discipline-specific Guidance for DMPs*. The working group identifies discipline-specific DMP characteristics and uses them to analyse common practices and differences in RDM horizontally across disciplines. Finally, we describe the approach of the *Research Data Management Organiser Sub-Working Group on Guidance*, which facilitates mapping of discipline-specific DMP templates across disciplines. Although these three approaches differ in their underlying concepts, combining them facilitates identifying differences and commonalities in RDM across disciplines. By assigning discipline-specific characteristics and mapping these characteristics across disciplines, the three approaches improve our understanding of data management and research data within a particular discipline, as well as across disciplines.

1 Introduction

As an integral part of good scientific practice, research data management (RDM) has become commonplace. RDM facilitates the reproducibility of findings and fosters the re-use of data by others by helping to make data FAIR (i.e., findable, accessible, interoperable, and re-usable). For instance, publishing open data and following the FAIR Data Principles[1] is required, e.g., in EU-Horizon 2020[2] and Horizon Europe[3]. Yet, researchers often lack knowledge on how to implement RDM activities appropriate to these goals.

One option to support researchers in processing FAIR data is to provide guidance with regard to writing and using a data management plan (DMP). Templates for such DMPs

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[1]Wilkinson, Mark D., Michel Dumontier, IJsbrand Jan Aalbersberg, Gabrielle Appleton, Myles Axton, Arie Baak, Niklas Blomberg, Jan-Willem Boiten, Luiz B. da Silva Santos, Philip E. Bourne, et al. "The FAIR Guiding Principles for Scientific Data Management and Stewardship". *Scientific Data* 3, no. 1 (2016): 160018. https://doi.org/10.1038/sdata.2016.18.

[2]European Commission. "H2020 Programme. AGA – Annotated Model Grant Agreement". June 26, 2019. https://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/amga/h2020-amga_en.pdf, last access: October 2, 2019.

[3]European Commission. "Horizon Europe (HORIZON) Euratom Research and Training Programme (EURATOM). General Model Grant Agreement EIC Accelerator Contract", Version 1.0. June 01, 2021. https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/agr-contr/general-mga_horizon-euratom_en.pdf, last access: August 26, 2021.

serve as a tool for planning, implementing and documenting RDM activities, aiming to guide researchers through their RDM activities. To date, such templates often focus on broad guidance but mostly lack specifics, e.g., neither referring to a certain type of data or a certain research object nor taking the requirements of a particular research discipline into account. Thus, it is not very surprising that researchers demand more tailored guidance and discipline-specific examples of RDM instead of using general templates[4,5].

Meaningful tailored guidance needs to take into account, among others, the particular research interests, the research objects examined, or the type(s) of data gathered. For instance, images or video records require different documentation than a data matrix, and humans or rare species make additional RDM activities necessary to protect such research objects and the information gathered.

Furthermore, such guidance should address the needs of a particular research discipline, including well-known and well-used methods to manage and share data in this discipline[6]. Tailored guidance needs to be as close to researchers' daily routines as possible, e.g., using researchers' language or providing concrete examples for their data management. DMP templates thus need to be discipline-specific to strengthen vertical integration of RDM activities. Vertical integration fosters RDM within a particular discipline, using discipline-specific terminology and providing discipline-specific guidance to ensure FAIR data within this discipline.

However, guidance should not only ensure vertical integration of RDM activities within a particular discipline. Data also have to be FAIR across disciplines. That is, guidance on RDM must ensure horizontal integration. Strenghtening vertical integration by providing detailed discipline-specific guidance may inadvertently reduce the comprehensibility of RDM activities and related research data across disciplines, e.g., in multi- or interdisciplinary research. Consequently, useful discipline-specific guidance must follow horizontal integration across disciplines. It must make it possible to map and compare RDM activities as well as data, and thus to ultimately re-use data across disciplines.

In this paper, we present three initiatives focusing on vertical and horizontal integration approaches to provide discipline-specific guidance while ensuring interoperability and cross-disciplinary understanding of RDM activities and related research data: We describe the project *Domain Data Protocols for Empirical Educational Research*[7] (DDPs),

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[4]Grootveld, Marjan, Ellen Leenarts, Sarah Jones, Emilie Hermans and Eliane Fankhauser. "OpenAIRE and FAIR Data Expert Group survey about Horizon 2020 template for Data Management Plans" (1.0.0) [Data set]. Zenodo. 2018. https://doi.org/10.5281/zenodo.1120245.

[5]Smale, Nicholas Andrew, Kathryn Unsworth, Gareth Denyer, Elise Magatova and Daniel Barr. "A Review of the History, Advocacy and Efficacy of Data Management Plans". *International Journal of Digital Curation 15*, no. 1 (2020): 30. https://doi.org/10.2218/ijdc.v15i1.525.

[6]Doorn, Peter. "Data Services to the Domains of the Humanities and Social Sciences and Beyond: DANS in the Netherlands". *Der Archivar*, (2020): 44-47.

[7]https://ddp-bildung.org/, last access: January 20, 2022.

following a concept of Science Europe[8], as an example for a vertical approach. The project develops tailored guidance on processing and sharing educational research data, focusing on the heterogeneity of data gathered, the sensitive research objects examined, and the specific requirements within the educational research discipline.

Following the approach of discipline-specific vertical integration, we further present the activities of the *Research Data Alliance Working Group* (RDA WG) on *Discipline-specific Guidance for DMPs* (DSGforDMP)[9]. The group collects and evaluates common practices and differences in RDM across disciplines via interdisciplinary discussions. Hence, the RDA WG investigates a cross-disciplinary understanding of data as well as of data management, improving horizontal integration.

Finally, we present the work of the *Research Data Management Organiser Sub-Working Group* (RDMO SWG)[10]. It gathers discipline-specific guidance for several disciplines and develops a concept of how to map guidance for inter- or multi-disciplinary projects, bringing together vertical and horizontal approaches.

2 Domain Data Protocols (DDPs): Discipline-specific Guidance for Educational Research

Domain data protocols (DDPs) aim to improve discipline-specific guidance, investing in vertical integration within a particular discipline. According to Science Europe, "DDPs are defined … as a 'model DMP' for a given domain or community that shares common methods"[11]. Most traditional DMP templates provide sets of questions on how data will be managed, e.g., asking researchers which identifier(s), such as a DOI[12] will be assigned to the data[13]. DDPs turn this approach over by providing concrete answers instead.

According to the concept of Science Europe, DDPs consist of 14 modules, grouped into categories, focusing, e.g., on data documentation and metadata, or on the resources and responsibilities for RDM[14]. Each module comprises of a minimal condition, best

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[8]Science Europe. "Science Europe Guidance Document Presenting a Framework for Discipline-Specific Research Data Management". 2018. https://www.rd-alliance.org/groups/discipline-specific-guidance-data-management-plans-wg, last access: January 20, 2022.

[9]https://www.rd-alliance.org/groups/discipline-specific-guidance-data-management-plans-wg, last access: January 20, 2022.

[10]https://rdmorganiser.github.io/, last access: January 20, 2022.

[11]Science Europe. "Science Europe Guidance Document", p.8.

[12]Digital Object Identifier System. "The DOI System". 2021. https://www.doi.org/, last access: August 25, 2021.

[13]EU-Horizon 2020. "Horizon 2020 FAIR Data Management Plan (DMP) Template". 2021. https://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/open-access-data-management/data-management_en.htm, last access: January 14, 2021.

[14]Science Europe. https://www.scienceeurope.org/, last access: March 17, 2021.

practise guidelines, use cases, and supporting resources on various RDM activities to reach the minimal condition.

However, the concept of DDPs is still in its infancy. As of today, we are aware of only a few projects developing DDPs, like the ARIADNEplus project[15] for the archaeologists or the project *Domain Data Protocols for Empirical Educational Research*[16] in Germany. Funded by the Federal Ministry of Education and Research[17], it brings together members of twelve research institutes, most of them directly involved in educational research and all of them involved in creating, managing or supporting research infrastructures. Once implemented in the *Research Data Management Organiser* (RDMO)[18], these DDPs will assist researchers of the educational research discipline in processing shareable data following the FAIR Data Principles.

The reasons to focus on educational research for developing such DDPs are manifold. First, educational research deals with highly sensitive research objects, e.g., children and teenagers. Second, it makes use of a large variety of different types of data, e.g., standardized surveys, observations, analysis of exams, or expert interviews, gathered face-to-face, by video- or audio recording etc.[19] Third, the most important funder for educational research in Germany, the Federal Ministry of Education and Research, requires data sharing since a couple of years[20]. In this context, the German Network of Educational Research Data[21], an infrastructure for data sharing, was established. It provides various guidelines and best practice advice on RDM activities and serves as a central starting point to develop DDPs for educational research.

While this development is still work-in-progress, members of the project have adopted the concept of Science Europe to the specific needs of the educational research discipline and developed major parts of the DDPs, so far. According to their approach, DDPs consist of two parts: A dynamic part describes the research project, the (types of) data gathered and the research objects examined. It can be used to compose a coversheet of a project's DDP, e.g., for funders, and provides metadata for data registration.

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[15]ARIADNEplus. "A Data Infrastructure Serving the Archaeological Community Worldwide". 2021. https://ariadne-infrastructure.eu/, last access: May 11, 2021.

[16]https://ddp-bildung.org/, last access: January 20, 2022.

[17]https://www.bmbf.de/bmbf/en/home/home_node.html, last access: January 20, 2022.

[18]https://rdmorganiser.github.io/, last access: January 20, 2022.

[19]Meyermann, Alexia, Doris Bambey, Malte Jansen, Reiner Mauer, Thomas Ebel, Marcus Eisentraut, Karoline Harzenetter, Poldi Kuhl, Claudia Neuendorf, Lisa Pegelow, et al. "Der Verbund Forschungsdaten Bildung – Eine Forschungsdateninfrastruktur für die empirische Bildungsforschung". 2017. https://www.konsortswd.de/wp-content/uploads/RatSWD_WP_266.pdf, last access: March 22, 2021.

[20]Federal Ministry of Education and Research. "Forschungsdaten Bildung". 2021. https://www.empirische-bildungsforschung-bmbf.de/de/3034.php, last access: January 14, 2021.

[21]German Network for Educational Research Data. "Verbund Forschungsdaten Bildung - VerbundFDB". 2021. https://www.forschungsdaten-bildung.de/index.php?la=en, last access: January 14, 2021.

The DDPs' second, static part follows a multi-level approach, as illustrated in Figure 1. On the initial level, each model contains a minimal condition on how data will be managed and made FAIR (at the end of the project). For example, the minimal condition on transparency (data documentation and cleaning) states[22]:

> *The data and accompanying materials are cleaned and documented in such a way that project members and third parties can 1) understand the entire data genesis, and 2) meaningfully interpret results based on it in (new) research contexts.*

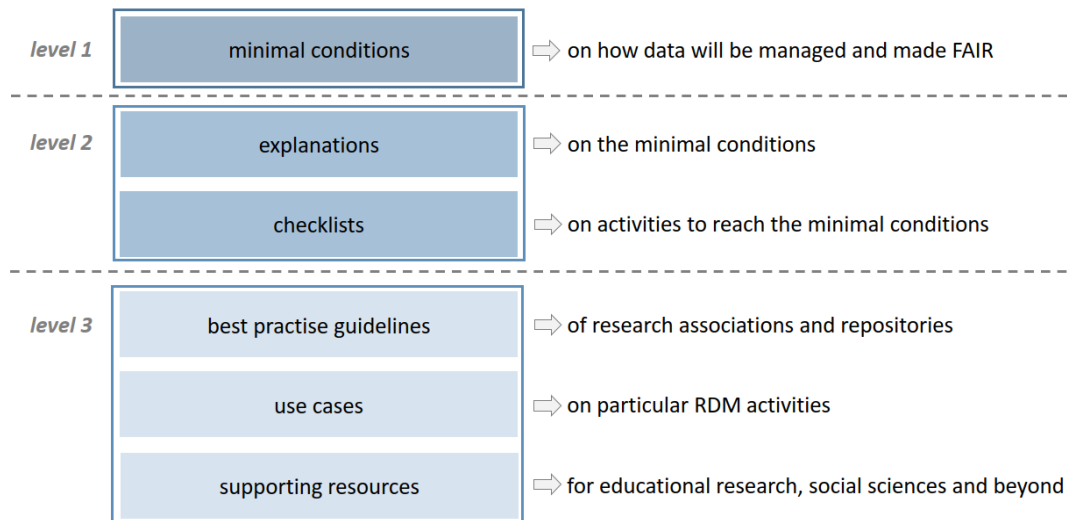| level 1 | minimal conditions | ⇒ on how data will be managed and made FAIR |
level 2	explanations	⇒ on the minimal conditions
	checklists	⇒ on activities to reach the minimal conditions
level 3	best practise guidelines	⇒ of research associations and repositories
	use cases	⇒ on particular RDM activities
	supporting resources	⇒ for educational research, social sciences and beyond

Figure 1: The multi-level approach of Domain Data Protocols for Empirical Educational Research

Such a minimal condition is quite abstract and it neither focuses on a particular research discipline nor on the type of data gathered or research objects examined. However, minimal conditions can be used in funding applications and serve as a reminder for well-experienced researchers and RDM experts of what to consider in their data management.

But for most researchers, the minimal conditions need to be further elaborated to provide concrete guidance on how to apply RDM. On a second level, each DDP module provides short explanations of the minimal condition as well as checklists with RDM activities to be implemented for reaching the condition. These checklists support researchers in planning and realizing their data management, depending on the type of data gathered and the research objects examined. For example, checklists to document audio or video records differ from those for documenting a data matrix.

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[22]Netscher, Sebastian, Anna Schwickerath, Anja Perry and Reiner Mauer. "Domain-Specific Data Management Plans and Cross-Disciplinary Interoperability". 2021. 16th International Digital Curation Conference (IDCC), virtual. https://doi.org/10.5281/zenodo.5137325.

Nevertheless, checklists hardly take the specific needs of the educational research discipline into account. On a third level, DDPs therefore contain best practice guidelines, use cases, and supporting resources related to educational research. Best practice guidelines include discipline-specific standards and guidance of repositories and research associations of the educational research discipline. Use cases based on educational research projects provide short examples of how to implement a particular RDM activity, such as documenting variables in a codebook. Finally, supporting resources link to existing standards, best practice guidance, data policies etc., addressing the educational and neighbouring research disciplines dealing with the same types of data and research objects.

In sum, the multi-level approach of DDPs for educational research considers different levels of researchers' experiences and knowledge on RDM by providing: Minimal conditions for funding applications, checklists supporting researchers in implementing RDM activities, and best practice guidelines, use cases and supporting resources providing tailored guidance on how to realize the various RDM activities in the context of educational research.

3 RDA WG Discipline-specific Guidance for DMP

In contrast to the vertical approach of DDPs, the RDA Working Group (WG) Discipline-specific Guidance for DMP primarily invests in horizontal integration. At the RDA Plenary P14 in Helsinki in October 2019[23], a discussion arose on how to adapt data management plans to make them easier to understand and complete for researchers. The participants of the joint meeting of the Active Data Management Plans Interest Group (IG), the Exposing Data Management Plans Working Group (WG), and the DMP Common Standards WG[24] identified discipline-specific aspects as a pressing challenge. As a result, the RDA WG *Discipline-specific Guidance for DMP* (DSGforDMP)[25] was formed with the aim of developing "discipline-specific guidance for DMPs to create a common understanding in particular disciplines and across disciplines for DMPs in general and in content aspects specifically".

To achieve this, a case statement including a working plan (see Figure 2), milestones, deliverables, stakeholders, etc. was elaborated. In this process, the co-chairs identified the Science Europe core requirements for a DMP[26] as a common starting point. In addition, some disciplines such as behavioural, educational, and social sciences,

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[23]https://www.rd-alliance.org/plenaries/rdas-14th-plenary-helsinki-finland, last access: January 20, 2022.

[24]https://www.rd-alliance.org/rda-14th-plenary-programme, last access: January 20, 2022.

[25]https://www.rd-alliance.org/groups/discipline-specific-guidance-data-management-plans-wg, last access: January 20, 2022.

[26]https://scienceeurope.org/our-resources/practical-guide-to-the-international-alignment-of-research-data-management/, last access: January 20, 2022.

engineering, chemistry (natural science), medicine, and biology (life science) could be selected as focal points, making use of the expertise of the co-chairs and the co-operation between the co-chairs and researchers from these disciplines. Exchanges between the RDA WG and other initiatives such as the DDPs, Science Europe, and the RDMO sub-working group on Guidance, as well as the bi-monthly public meetings, extended the discussions to additional disciplines. Likewise, presenting the WG at various events such as the eScience Days 2021[27] or the RDMO-NFDI Workshop 2021[28] facilitated networking, leading to an increase to 51 group members.

The group outlined five work packages in the working plan (see Figure 2). The first two work packages relate to establishing the working group within the RDA and in other communities, while the work packages three to five, address the discipline-specific adjustments.
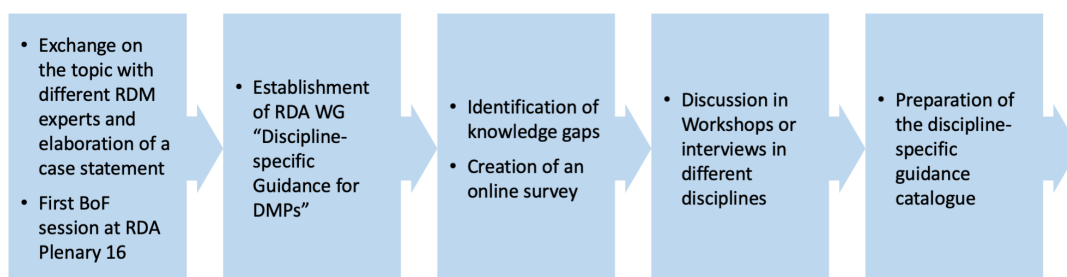

Figure 2: Working plan of the RDA WG DSGforDMP

In work package three, the WG identified some knowledge gaps and developed an online survey to further specify the findings. The survey consists of 22 questions and is structured into the five sections:

- demographics,
- data description and collection,
- data documentation and quality,
- data archiving, publishing and sharing after the project as well as
- guidelines, principles and best practices.

The survey was developed iteratively with different researchers and stakeholders. For instance, a first draft was discussed at the RDA Plenary P17 in April 2021 and after-wards reviewed in an open meeting. The survey was open for response until mid-January 2022. The evaluation of the results is currently taking place.

The online survey does not focus on a certain discipline. Through the online survey, discipline-specific standards will hopefully be identified and will be added to the guid-ance catalogue. On the one hand, the catalogue is intended to show different focal points within a discipline. The granularity of the information in a DMP (template) of

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[27]https://e-science-tage.de/de/programm_2021, last access: January 20, 2022.
[28]https://rdmorganiser.github.io/docs/nfdiws/workshop-nfdi/, last access: January 20, 2022.

a discipline and the links to other existing systems, if any, should be shown. By looking at different disciplines in detail, cross-disciplinary features can be identified. With hopefully broad participation from many disciplines, this information can be included in the catalogue so that an inter- or multidisciplinary project can pick and choose the assistance, standards, policies, etc. that are appropriate for their disciplines. Due to the focus on the core requirements, it can be applied to all templates. In addition to the online survey, the RDA WG will offer workshops or interviews to interested parties to extend and enrich the survey results (work package 4), compensate for the disadvantages of an online survey, and to validate the results[29]. The results of the online survey and the workshops or interviews will be compiled and used to develop the discipline-specific guidance catalogue (work package 5).

The RDA WG DSGforDMP has announced to publish the discipline-specific guidance overview in March 2023. The guidance catalogue will not only support researchers in writing DMPs, it will hopefully also provide initial orientation for disciplines that are just starting to apply the concept of DMPs. Therefore, other stakeholders are data stewards, data managers and generic RDM support teams.

4 RDMO Sub-Working Group on Guidance

DMPs are typically managed in specific (web-based) tools, like the Research Data Management Organiser (RDMO)[30]. As a community-driven project, the development of the open-source RDMO software brings together an interdisciplinary group of researchers, software developers and RDM experts working collaboratively on DMP aspects and related tool features of RDMO. It thus brings together vertical integration, providing tailored guidance for a particular discipline by discipline-specific DMPs, and enables horizontal integration by mapping DMPs of different disciplines.

The idea of the *RDMO Sub-Working Group (SWG)* on Guidance came up in late 2020 and the work started in April 2021. The *RDMO SWG* addresses the gap between funder- or policy-driven DMP templates and practice-oriented discipline-specific RDM activities (see Chapter 1). The overarching goal of the *RDMO SWG* is to develop and share discipline-specific written manuals and guidance. These can then apply to interdisciplinary projects. To achieve this goal, DMPs from selected disciplines such as environmental sciences, linguistics, and chemistry, structured according to the Science Europe template[31], will be analysed. Here, the focus is on the guidelines in data management practice and the associated consequences. From the analysis, text modules

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[29]Zerr, Konrad. "Online-Marktforschung – Erscheinungsformen und Nutzerpotentiale". In *Online-Marktforschung: Theoretische Grundlagen und praktische Erfahrungen*. Eds. Axel Theobald, Marcus Dreyer & Thomas Starsetzki, 7-26. Wiesbaden: Gabler, 2003.

[30]https://rdmorganiser.github.io/, last access: January 20, 2022.

[31]https://www.scienceeurope.org/media/4brkxxe5/se_rdm_practical_guide_extended_final.pdf, last access: January 20, 2022.

for the selected disciplines should be provided to facilitate the creation of meaningful DMPs that are as discipline-specific as necessary while at the same time still compatible with other disciplines. To use this in a researcher-friendly manner, the *RDMO SWG* is currently developing a faceted filtering approach that will allow researchers to select guidelines for multi- or interdisciplinary projects by selecting relevant disciplines and DMP topics and filtering for appropriate guideline elements.

For example, in the environmental sciences (ES) a DMP covers the aspects data description and collection as well as documentation and data quality. Taking documentation and data quality as an example, choosing a suitable metadata schema and/or developing a proper metadata profile is a relevant task at the beginning of each project with extensive consequences. Here, several specific metadata schemas – well-known and well-used in environmental sciences – are available, like GeoDCAT[32] or DIN EN ISO 19115-1[33], providing common structured elements, e.g., title or abstract, and specific elements, e.g., spatial or temporal resolution. For relevant aspects, like data quality, these schemas enable either applying linked specific schemas or using generic vocabularies, e.g., DIN EN ISO 19157[34] to describe the quality of geospatial data spatially or temporally explicit or the Data Quality Vocabulary (DQV)[35] to follow a cross-disciplinary quality description approach. Finally, it is up to the researchers to choose one of the plenty metadata schemas (and linked ones), decide on the need of developing a metadata profile and be aware of all related consequences. Thus, the WG gathered guidance information for ES metadata including

(1) a list of available discipline-specific and cross-disciplinary metadata schemas[36] enabling researchers to select a proper schema according to their (disciplinary and/or project) needs,

(2) pointing out the relevance of taking the schema decision early in the project, e.g., for setting up data management tools used for sharing and describing research inputs, and

(3) consequences of choosing specific schemas, like addressing the gap between compatibility and information loss to other linked (long-term) repository schemas or pointing out the relevance of specific metadata elements for automated metadata extraction (tools), discovery mechanism, and data publication services.

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[32]https://semiceu.github.io/GeoDCAT-AP/drafts/latest/#properties-for-dataset, last access: January 20, 2022.

[33]International Organization for Standardization. "Geographic Information – Metadata – Part 1: Fundamentals". 2014.

[34]International Organization for Standardization. "Geographic Information - Data Quality (ISO 19157:2013)". First edition, Geneva: 2013.

[35]http://www.w3.org/ns/dqv, last access: January 20, 2022; https://www.w3.org/TR/vocab-dcat-2/#quality-information, last access: January 20, 2022.

[36]Similar to the Metadata Guideline for Earth System Sciences: https://doi.org/10.5281/zenodo.4916697.

Currently, the sub-working group is gathering similar information and guidance for further disciplines and tackling open challenges, in particular:

- How to structure discipline-specific information within Science Europe core requirements to ensure the compatibility across disciplines, while following discipline-specific concepts at the same time, as intended by DDPs.
- How to describe/summarize certain project types (e.g., internal, external, field study) when assigning relevant guidance to enable researchers to select the correct project type and receive a pre-defined set of guidance.
- How to ensure that all discipline-specific needs are addressed and all discipline-specific information is included in the extendible guidance structure.
- How to integrate and link discipline-specific vocabulary or different discipline-specific definitions for a common vocabulary.

5 Bringing vertical and horizontal integration together

In recent years, more and more funders and institutions have specified and developed DMP templates to support researchers in processing and sharing data, and to implement sustainable data management. To date, most DMP templates remain on a quite abstract level, hardly enabling researchers to write a DMP, to understand necessary RDM activities, and to select proper activities for their data and research objects, according to their discipline.

Most of these DMP templates were developed independently, without any discipline-specific focus, and differing in their structure and granularity. Consequently, such templates can hardly be compared. In consequence, the re-use of existing DMPs (sections) in new projects, which is crucial in multi- or interdisciplinary research in particular, is hampered. Hence, many researchers have perceived writing a DMP as a bureaucratic burden.

The three projects presented address these challenges by applying different approaches. To improve tailored guidance, the project *Domain Data Protocols for Empirical Educational Research* follows a vertical approach by addressing the needs of a certain discipline, making use of researchers' knowledge on RDM, and providing discipline-specific guidance on implementing RDM activities. But the approach of DDPs hardly takes horizontal integration into account. At a first glance it neither facilitates comparability or even mapping of RDM activities across disciplines, nor does it foster data re-use in multi- or interdisciplinary research. However, although the DDPs for educational research focus on educational research exclusively, parts of the protocols can be adopted and further developed by other (neighbouring) disciplines, such as the conditions on managing and making data FAIR.

In contrast to the DDP approach, the *RDA WG DSGforDMP* primarily focuses on horizontal integration aspects. Its online survey reaches out to stakeholders from a wide

range of different research disciplines. Consequently, the RDA initiative examines the comparability of RDM activities and data across disciplines. It is not yet clear how many stakeholders from which disciplines will participate. Therefore, the validity of the results might be lower for some disciplines if these are not well-represented in the data.[37]

In comparison, the approaches of the DDP project and the one of the *RDA WG DSGforDMP* can be expected to be complementary. The DDP approach focuses on vertical integration, aiming to assist researchers in educational research by providing tailored guidance. The *RDA WG DSGforDMP* examines differences and common practises across disciplines, investing in horizontal integration. To improve RDM, vertical and horizontal integration must be combined. For example, while the DDP project provides tailored guidance on documenting data to ensure transparency according to the needs of the educational research discipline, the *RDA WG DSGforDMP* figures out the different meanings of data and any implications for data documentation for different disciplines. Identifying such differences and common practises is core to ensure that RDM activities can be mapped between disciplines, e.g., in interdisciplinary research.

Technical solutions facilitate bringing together discipline-specific guidance, i.e., vertical integration, and the mapping of differences and common practises in RDM across disciplines, i.e., the horizontal approach. Accordingly, the approach of *RDMO SWG on Guidance* enables vertical integration by providing discipline-specific DMP guidance in RDMO and linking this vertical guidance horizontally with guidance from other disciplines. The RDMO sub-working group thus combines vertical and horizontal integration by making discipline-specific guidance comparable and mappable across disciplines.[38] And even though the *RDMO SWG on Guidance* currently addresses only a few, selected disciplines, it is a first step to make RDM activities and data more comprehensible, understandable and interoperable across disciplines, thereby fostering multi- or inter-disciplinary research.

In conclusion, we expect both horizontal and vertical approaches to be complementary. Combining them will facilitate our understanding as well as the development of tailored, discipline-specific guidance. At the same time it will create opportunities to map and transfer this guidance horizontally from one discipline to another, to increase our understanding of data and data management across disciplines. And even though each of the three ongoing initiatives presents a different perspective on discipline-specific DMPs (templates) and cross-disciplinary aspects, existing gaps of one perspective can be (at least) partially compensated in combination with the other initiatives.

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[37] If you are interested to participate, please contact Daniela Hausen or Ivonne Anders via https://www.rd-alliance.org/groups/discipline-specific-guidance-data-management-plans-wg, last access: January 20, 2022.

[38] If you are interested to participate, please contact Christin Henzen or Ivonne Anders via ORCID.

In sum, ensuring vertical and horizontal integration requires a general effort to provide tailored guidance within a particular discipline as well as to enable mapping of RDM activities across disciplines. Since many RDM activities described in DMPs are still under development - at least in some disciplines - tailored guidance needs to be constantly reviewed. As a consequence, the involvement of initiatives that work with DMPs, such as consortia of the German National Research Data Infrastructure (NFDI)[39], Science Europe or the European Open Science Cloud (EOSC)[40] is key in the creation of understandable and comprehensible DMP templates. Such investments in vertical and horizontal integration will yield a win-win situation for the whole research community, resulting in a better understanding of data within as well as across disciplines.

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[39] https://www.nfdi.de/?lang=en, last access: January 20, 2022.
[40] https://eosc-portal.eu/, last access: January 20, 2022.