Research Data Management Practice in Academic Libraries

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LITERATURE REVIEW ARTICLE

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ABSTRACT

Purpose: The present scoping review examines research data management (RDM) best practices and empirical studies in academic libraries between 2010 and 2021.

Method: The current study developed systematic database searches to locate potential articles for inclusion and designed a detailed and systematic coding scheme to examine the substantive features of RDM and characteristics of RDM practice, with an emphasis on RDM instruction.

Results and Discussion: The results from the current study demonstrated that there is great demand for RDM training after 2011. Furthermore, research about RDM training spread across North America, Europe, Asia Pacific, and elsewhere. The findings also proved that RDM training is essential for both STEM and non-STEM subjects but simultaneously indicated that non-STEM subjects such as the social sciences in particular lack RDM training. Results from the current literature also found that a large number of RDM training programs focused on the introduction of RDM or an RDM overview, without in-depth and discipline-based curriculum for researchers across domains. Additionally, this study identified a lack of quantitative research, especially statistical analysis, on the effect of RDM interventions.

Conclusion: This study contributes to our comprehensive understanding of some essential elements associated with RDM training, with the primary finding that future practitioners in the RDM field would benefit from stronger collaboration with faculty or researchers to develop more discipline-based curriculums for RDM and more application-based approaches for teaching RDM.

Keywords: research data management, academic libraries, data literacy, scoping review

INTRODUCTION

Research data management (RDM) involves various practices and activities connected with the lifecycle of data, including its creation, collection, storage, quality control, sharing, and so on (Cox & Pinfield, 2014; Whyte & Tedds, 2011). RDM also takes into consideration technical capabilities, ethical and legal issues, and governance policies related to research data (Pinfield et al., 2014). As noted by Whyte and Tedds (2011, p. 1), the purpose of RDM is to "ensure reliable verification of results and permit new and innovative research built on existing information." Because RDM plays a critical role in government, industry, and academia, the importance of RDM has been recognized more and more over the last decade (Belter, 2014; Wilson & Jeffreys, 2013).

RDM is widely perceived as having three primary characteristics. First, it is closely involved with all aspects of procuring and preserving research data; second, it is heavily involved in the creation of research materials derived from the collection of primary data or from existing sources (Corti et al., 2014; Gunjal & Gaitanou, 2017); and, finally, it is considered to be stored knowledge owing to its use in research publications (Kuula et al., 2008). As academic libraries are becoming a critical role in supporting research needs through RDM (Chabot et al., 2016), it is essential that academic libraries that are viewed as a significant stakeholder in the RDM landscape take on the responsibility of further enhancing RDM.

LITERATURE REVIEW

The Importance of RDM Training in Academic Libraries

The new role of academic libraries as the hub or control center of data stewardship embedded in the research enterprise is clear (Giarlo, 2013; Hey & Hey, 2006; Pryor et al., 2013). As a result, these specialized libraries have had to focus on providing RDM initiatives and resources at every stage of the research lifecycle, an effort that has resulted in more support of data management plans, more guidance in area of open access data, and more partnerships with peer stakeholders across the domain of data discovery and reuse (Chabot et al., 2016). This process also necessitates stronger partnerships with stakeholders across disciplines, including information technology, research, and funding, throughout the institution's entire RDM enterprise (Pinfield et al., 2014; Gunjal & Gaitanou, 2017).

Chabot (2016) and colleagues have noted that academic libraries, along with funding organizations and other units in the academic enterprise, play an essential role in supporting research needs through RDM. In the case of libraries in particular, this entails providing RDM training and tools to users, as well as overseeing all aspects of the RDM process from discovery to

archiving (Mitchell, 2013; Repository Task Force, 2009). This has created a need for academic libraries to continually match researchers with their relevant counterparts and with the data services they require and to investigate current RDM activities—difficult challenges that nevertheless are an important contribution to RDM's overarching purpose.

To date, as academic libraries have increased the scope of their RDM efforts, they have focused primarily on training and related activities (Si et al., 2015) provided in a variety of ways (Tenopir et al., 2017). These include a pilot program described by Read et al. (2019) that provided RDM resources, strategies, and support in addition to training for 26 librarians at six university libraries via online and in-person activities. The pilot program was deemed successful in the domains of teaching librarians about RDM, increasing their RDM engagement within their research communities, developing their skills to teach RDM, and entering partnerships for RDM services with others in the institution. In their study of RDM training offered to more than 300 research faculty at the University of Minnesota Libraries, for example, Johnston et al. (2012) found that academic libraries can provide such support through federal mandates pertaining to the timely dissemination of research data, discussion-based training, and the development of data management plans. Whereas studies such as this have proven useful in the past, many academic librarians report that they lack the skills, competencies, and training to handle the profound increase in the scope and breadth of RDM services over the past decade or so (Tenopir et al., 2012; Tenopir et al., 2013, 2014), clearly indicating the critical need for training and support of librarians (Poole, 2015).

Furthermore, fulfilling the fundamental academic mission of preparing future generations of researchers will require the extension of RDM education into the student population. For example, a librarian and a faculty member offered in-depth RDM training to graduate students in an approach that provided the benefit of both specific, real-life research applications and a general, high-level overview at the University of Wyoming, Laramie (Schmidt & Holles, 2018). Although the students improved their understanding of RDM and its uses, suggesting that RDM training is a worthwhile addition to the graduate research curriculum, this type of training is still very limited (Pasek & Mayer, 2019; Phillips et al., 2019; Poole, 2015; Xu et al., 2022).

Previous Reviews of RDM

This section summarizes the current RDM research to identify the factors that contribute to its success and lack of success in order to make recommendations for future work. In 2015, Poole reviewed the literature regarding data sharing, access, and reuse processes and their benefit to scientific fields in academia in North America and the UK, with a specific focus on the infrastructure of data curation, data archiving, and repositories in academic libraries. Poole discussed

the challenges of digital curation and suggested further research in the areas of sustainability, finance, planning and policy, training and education, researcher practices, and awareness.

In 2017, Perrier et al. conducted a scoping review of RDM in academic institutions regarding its volume, topics, and methodological nature from inception to 2016, including 301 articles and 10 reports. This study found that the majority of articles published in 2010 and later were within specific scientific disciplines, and that the most-used data collection instruments were case studies and interviews. They also identified that empirical evidence pertaining to data producers was the least-studied aspect of research in the RDM field, especially regarding the result of RDM interventions. In addition, less research was conducted on the use of RDM in the initial stages of the research process.

In addition, Perrier et al. (2018) conducted a meta-ethnographic review of 12 qualitative studies of academic libraries with RDM experience and found that, whereas RDM is increasingly critical to the function of academic libraries, significant challenges remain, such as a lack of funding and other resources, as well as infrastructure issues such as data storage and quality. They also found that the library was viewed favorably by both library professionals and staff and by researchers, indicating that strengthening the relationships between libraries and other stakeholders could prove mutually beneficial. Although this study provides a greater understanding of libraries that offer RDM services, one must keep in mind that the review is quantitative only, providing a description and list frequencies of RDM activities, and do not provide a larger context for interpreting the findings.

In 2019, Goben and Griffin had a thorough review of studies related to RDM surveys and reported that 66% of its sample included outcomes as the effect of the activities that the library implemented based on the results of the needs assessment conducted in the institution. After reviewing 37 case studies related to the assessment of RDM in academic institutions, RDM topics related to data storing, sharing, and maintaining long-term access to data are ranked as the top needs. Results also indicated that RDM training and education were requested as a need among almost half of the included studies, implying the need for more formal RDM instruction, especially for researchers in their early career stage and students who work with data and are developing their skill.

In 2020, Ashiq et al. conducted a systematic literature review of 19 studies of RDM practices and services and found that academic librarians and researchers generally lack the skills to fulfill the potential of their RDM responsibilities, although the situation was better in developed countries than in developing countries. The researchers recommended active collaboration between university libraries and other RDM stakeholders as a way to mitigate this situation.

Because RDM is increasingly important to academic libraries' functions and those of researchers, a comprehensive and thorough review of studies on RDM training in academic libraries is imperative. Previous reviews indicated that little is found in the literature about RDM training in the context of academic libraries in higher education beyond some literature reviews focused on RDM services and practices. Additionally, previous reviews of RDM-related topics centered solely on either qualitative or quantitative studies. Therefore, a combination of both types of articles in a systematic and comprehensive review of literature in RDM studies—including both best practices and empirical articles—may be needed to comprehensively understand the current status of RDM training.

The present scoping review, therefore, examines RDM best practices and empirical studies. Through a systematic coding scheme on existing literature on RDM in academic libraries, the current review attempts to investigate the included studies' substantive features, as well as RDM's aspects and effects, and the characteristics of those who use RDM along with their learning context. The current study is guided by the following research questions:

- What are the fundamental characteristics of these published studies (journal information, primary geographic region, and subjects directly related to RDM practice)?
- Which are the characteristics of the RDM practices, such as RDM aspects and RDM target audiences?
- What are the characteristics of the RDM instruction? What is the format? What is their effect? What are popular topics in RDM instruction?

METHOD

The research questions focus on RDM in academic libraries. The review included all kinds of studies, such as best practices and empirical research, and then summarized the findings using descriptive statistics (Arksey & O'Malley, 2005). The scoping review method was determined to be best for this purpose.

The scoping study framework of Arksey and O'Malley (2005) was used. First, we classified the research questions. Then, we searched for and selected relevant studies from different databases. Next, we designed an assessment scheme to ensure the quality of the studies included. Subsequently, data from the included studies was charted using a coding form, and elements from it were summarized and reported in the results. For reporting, we followed the PRISMA-ScR checklist for methodological transparency (Tricco et al., 2018). The PRISMA-ScR checklist contains 20 essential reporting items and two optional items to include when completing a scoping review."

Literature Search

We developed systematic database searches to locate potential articles. The search was developed in LISTA (Library Information Science and Technology Abstracts) and modified for Medline Complete and Association of College and Research Libraries (ACRL) Conference Proceedings. The three searches were "research data management, higher education, and academic libraries". Closely related terms for each were searched in the title and abstract fields, whereas the following database subject terms were searched in the subject field: "data management, data curation, data preservation, data repository, research data, data literacy, workshop, train, and professional development" (see Appendix A). Each database search was limited to January 1, 2010, to May 18, 2021. The combined searches retrieved 1,541 results. After the database search, we manually searched Journal of eScience Librarianship, which contains numerous articles about RDM but is not indexed in the searched database, and found 59 articles. After removing duplicates, a total of 1,531 records were included in the initial search.

Quality Assessment

Some studies generate adequate contributions to the field, whereas others produce biases. Therefore, the quality of the research methodology of the included articles was explicitly and systematically assessed, specifically in the stage of full-text screening, using a scoring instrument adapted from the Methodological Quality Questionnaire (Acosta et al., 2020). This reflected the quality of the evidence within each study and provided a general score of methodological quality. For empirical studies, we used the adapted version that covers eight categories to evaluate the quality: theoretical/conceptual framework, statement of the problem, research design, sample of the target audience, data collection/analysis, results, evaluations of the findings, and implications. For best practice studies, we used the adapted version that covers 5 categories to assess the research quality: theoretical/conceptual framework, statement of the problem, RDM stakeholders of the practice, detailed description of the practice procedures, and evaluation of the practice, either from the objective or subjective perspective. Each category was assessed on a three-point scale from $0 =$ No, over $1 =$ Partial, to $2 =$ Yes. Studies that scored above 70% of the full score (16 points for empirical studies and 10 for best-practices studies) were included in this review. Additionally, if one category was scored zero, the studies were excluded.

Inclusion Criteria

To be included, the studies had to meet the following criteria. First, they must investigate the RDM-training studies at academic libraries. Articles were excluded if their topics were not

about RDM training or if they were not under the context of academic libraries. The format of the included studies could either be an empirical study or a best practice study of RDM training. Articles were excluded if they only reported about a course or workshop about RDM and did not include any evaluation to the courses or workshops. Articles that generally discussed the trends or the importance of RDM were also excluded.

Second, the studies had to be published in a journal or conference between January 1, 2010, and May 18, 2021, and available in English. The National Science Foundation (NSF) required a Data Management Plan beginning in 2010 (NSF 11-1, 2011), generating a great deal of scholarly interest at academic libraries. Secondary data analysis, literature reviews, book chapters, and reports were excluded.

Finally, only studies conducted within academic libraries in higher education were included; those in the context of public libraries, secondary education, or corporate management were excluded.

Coding Scheme

The information was organized using a detailed coding format that made data extraction more efficient. First, we used the form to address any substantive features. To address the study's focus on RDM trends in libraries at research universities, we created categories for the RDM target audience and the RDM aspects. Finally, we created a comprehensive coding scheme that captured the characteristics of RDM instruction in the RDM instruction.

Substantive Features of the Studies.

The following substantive features were identified: article format, publication information, country/region of the study, and RDM-related subjects.

We first classified the article format as best-practice articles or empirical studies, adhering to Allen et al.'s (2018) definition that empirical research is "any type of data collected for the purpose of research." Articles on empirical studies have a specific research method with either qualitative or quantitative approaches to clearly answer the research questions with the evidence collected.

Next, we coded the article type as a journal article or conference article. We coded the journal titles or conference names to identify the major journals/conferences contributing to the field. We also recorded the publication years to determine any trends in the publication of RDM training research in higher education. For the country/region in which the study was

conducted, we attempted to examine whether the trends of RDM training in academic libraries differed across countries/regions. We coded RDM related subjects as STEM (science, mathematics, engineering, and technology) and non-STEM (Vo et al., 2017). Studies were coded as mixed if they covered general subjects including both STEM and non-STEM subjects. STEM subjects included Earth science, chemistry, natural and physical sciences, and so on, whereas non-STEM subjects included political science, social sciences, and business and economics.

RDM Audience and Aspects.

RDM target audiences were categorized based on professional role: faculty/researchers, graduate students, undergraduate students, and librarians. RDM aspects were coded based on the DataONE data lifecycle (DataONE, n.d.): data collection, data management plan, data analysis and visualization, and data sharing (including data curation/preservation/repository). For both audience and aspect, any unit that was in more than one category was coded as mixed.

RDM Instruction.

In studies for which the audience received instruction, we coded the learning context based primarily on the platform upon which the studies were conducted: face-to-face for the traditional classroom model, online for computer-based instruction, and hybrid for both. If the platform was not identified, the study was coded as not clearly defined.

We further coded the instruction target audience as faculty or researchers, graduate students, undergraduate students, or librarians. Those from two categories were coded as mixed. We also coded the provider of the instruction as librarians, researcher or faculty, or mixed.

The instruction format was categorized as a course or workshop/seminar. We coded the duration of the instruction, whether it was a one-time training (or workshop) or a series of seminars/workshops (coded as a series). Additionally, courses were also coded as credit-bearing, non-credit, or not indicated.

The effect of RDM training was coded as negative, positive, or mixed, and how the RDM training was evaluated was coded as quantitative (using descriptive statistics or statistical analysis, per Brattin [1991] and Chu [2015]), qualitative, or mixed. Studies that used both were coded as mixed methods.

We also categorized the topics of RDM instruction to identify which were most popular using the categories of data management plan, data sharing, data analysis and visualization, data

documentation, data storage, data quality, ethics, RDM tools, and data security. If the RDM instruction was an overview of RDM or introduction to RDM, we coded it as an RDM overview. Articles that listed webinars, workshops, or courses about RDM but did not specify what this instruction covered were coded as unspecified.

Data Collection and Data Analysis

After search and deduplication, a total of 1,541 unique references were screened for eligibility. We also manually identified 59 articles from Journal of eScience Librarianship because it is a major journal in the RDM field but not indexed in our database. The author and one graduate assistant screened the article titles and abstracts using the inclusion/exclusion criteria. The first round of screening excluded more than 90% of the articles. The author and the graduate assistant then independently screened the full text of the remaining 370 articles and determined that 101 articles were eligible for inclusion (see Figure 1).

The author and the graduate assistant then used the developed coding scheme to code the articles in Microsoft Excel. Cohen's Kappa was used to test interrater reliability. They reached Kappa = 1.00 on most of the coding categories except for approaches in evaluating the RDM aspects (Kappa = 0.912), RDM instruction providers (Kappa = 0.931), and duration of RDM instruction (0.919). Interrater reliability (McHugh, 2012) for the Kappa statistics was found to be strong to almost perfect (from 0.878 ~ 1.00). Finally, the research questions were answered using descriptive statistical analyses.

RESULTS AND DISCUSSION

Findings of the Substantive Features of the Studies

Publication Information.

Of the 101 articles included, 49 (48.51%) covered best practices and 52 (51.49%) were empirical studies. A trend of increased RDM training and research in research libraries beginning in 2010 was uncovered based on the publication year of the studies included. A total of 36 articles (35.64%) were published between 2010 and 2015, and the other 65 articles (64.36%) were published between 2016 and 2021. Many funding agencies require grant applications to include data management plans for preserving research data and making it widely available, and this also was required under an executive order and pending legislation in 2011 and 2013 (NSF 11-1, 2011; Diekema et al., 2014). Therefore, the significant increase in demand for RDM training that was identified was to be expected. We saw one article about RDM training in 2010, three articles about RDM training in 2011, four in 2012, and four in 2013. However,
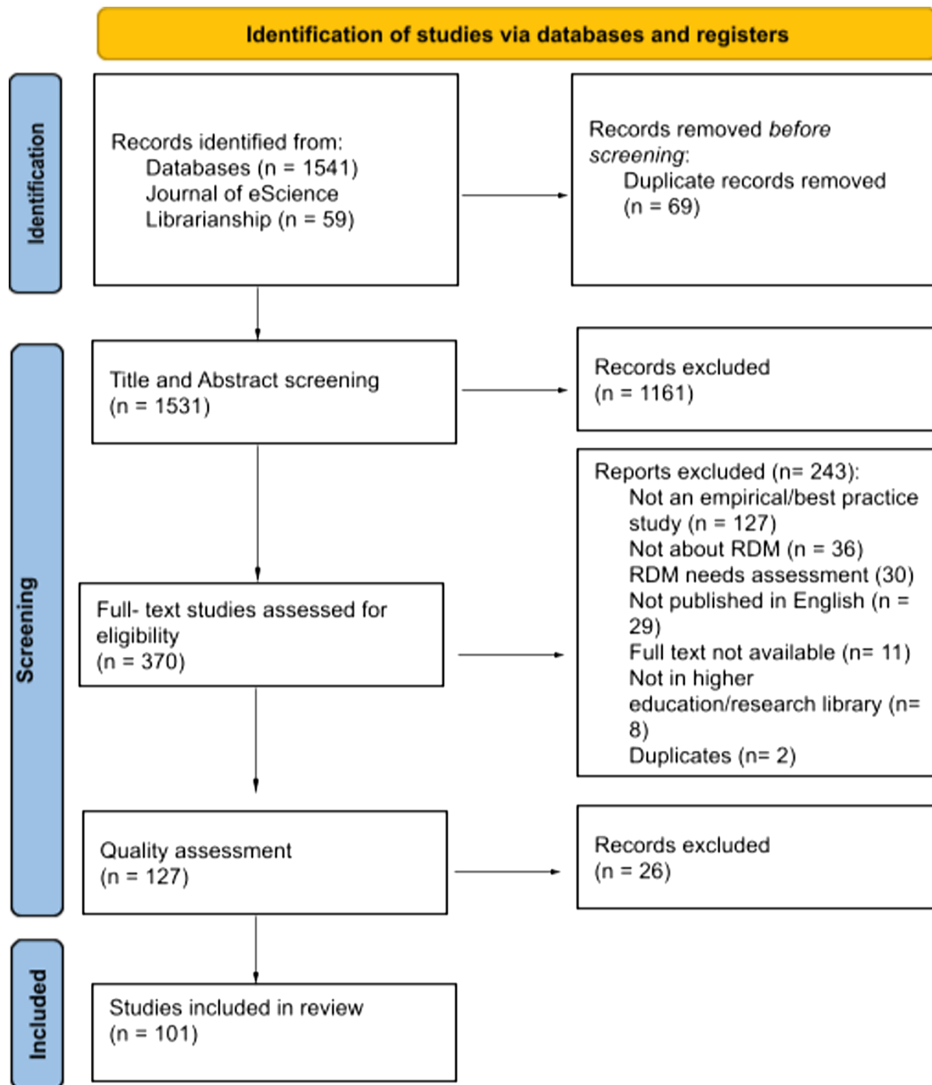
Figure 1. PRISMA Flow Chart.

we saw an obvious increasing trend starting from 2014. There were 89 articles about RDM between 2014 and 2021, with an average of almost 11.13 articles per year (see Figure 2).

Among the 101 articles, 95 (94.06%) were from 36 peer-reviewed journals, and the other 6 (5.94%) were conference papers from the American Society for Engineering Education (ASEE), the International Association of University Libraries (IATUL), and the ACRL. The majority of the journals ($n = 25$) appeared once. The other 11 journals showed up more than once, with 70 articles (see Table 1).

Number of Publication by Year
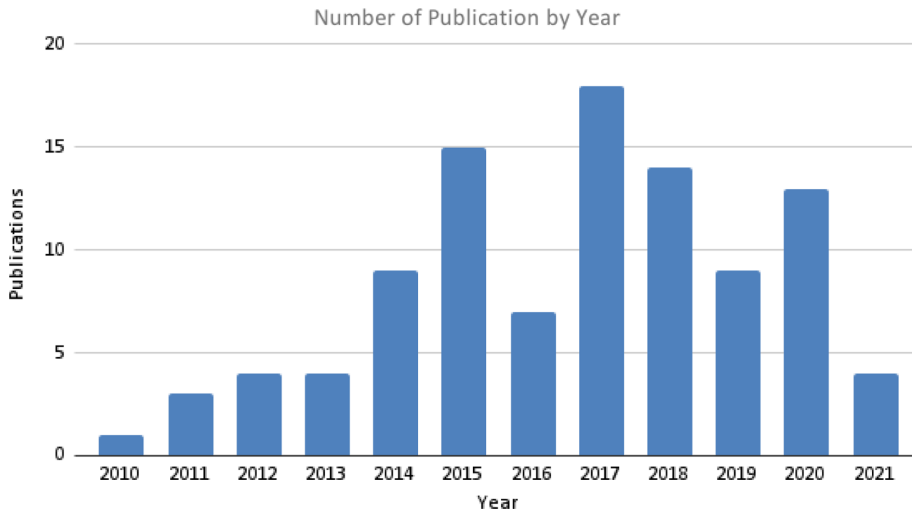
*Note: Publications of 2021 is reviewed for partial of the year in this study
Figure 2. Publications by Year.

Journal	Number of articles included in the review
Journal of eScience librarianship	32
Journal of Librarianship and Scholarly Communication	9
Journal of the Medical Library Association	5
PLOS One	4
IFLA journal	4
Program: electronic library and information systems	4
New Review of Academic Librarianship	3
Journal of the Australian Library and Information Association	3
The Journal of Academic Librarianship	2
D-Lib Magazine	2
Chemical Engineering Education	2
Other journals (articles appeared once) (e.g., Journal of Web Librarianship, Library Management)	25*

Conferences	Number of articles included in the review
American Society for Engineering Education Conference	4
Association of Research Libraries Conference	1
International Association of University Libraries Conference	1

*Other articles only appear once, but in separate journals
Table 1. Journals and Conferences of Included Articles.

Substantive Characteristics of the Included Studies.

The majority of the studies were conducted in the United States ($n = 70$, 69.31%). The following regions appeared more than once: Australia ($n = 6$, 5.94%), the UK ($n = 5$, 4.95%), France ($n = 3$, 2.97%), Canada ($n = 2$, 1.98%), and Germany ($n = 2$, 1.98%). The other seven articles (6.93%) were from Indonesia, Switzerland, South Africa, Taiwan, the Netherlands, Zimbabwe, and Iceland, and appeared only once. Six articles (5.94%) were conducted in the context of more than one country and/or region.

Given that the US issued federal mandates requiring RDM considerations, it was anticipated that the majority of studies in North America would be conducted there (71.29%, $n = 72$). Other regions where the number of RDM-related studies increased were Europe (with 7.92%, $n = 8$) and Asia-Pacific (7.92%, $n = 8$). Furthermore, 1.98% ($n = 2$) of articles originated in Africa. As noted, studies from more than one region or country made up 5.94% of the studies ($n = 6$) considered. No studies of RDM training originated in Latin America (see Figure 3).
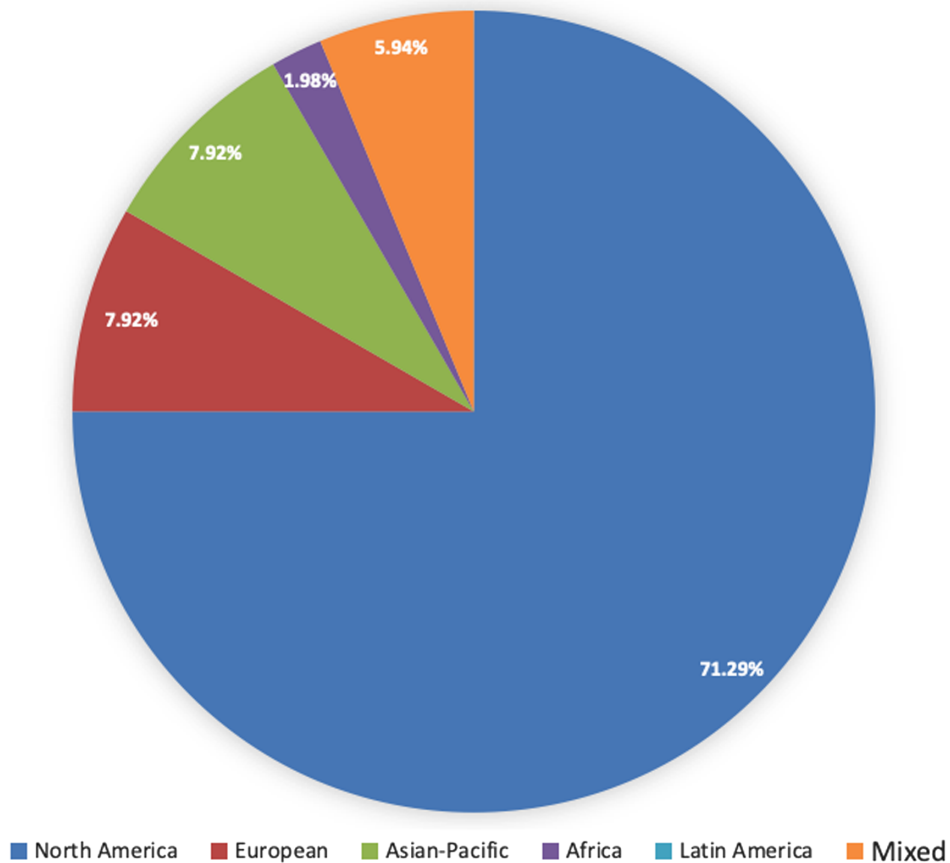

Figure 3. Location of Included Articles by Area.

For RDM training in disciplines, 24 articles (23.76%) addressed STEM subjects, whereas four articles (3.96%) addressed non-STEM subjects. The other 73 (72.28%) were mixed, underscoring the tremendous need for RDM training across disciplines (Poole, 2015; Tang & Hu, 2019). In the present scoping review, STEM subjects include general engineering, general science, health and medicine science, chemistry, neuroimaging, Earth science, aerospace engineering, environmental science, biomedical, information systems, natural and physical sciences, and mixed STEM, whereas non-STEM subjects include economics, business, political science, ecology and evolution, and general social science. This finding clearly highlights the need for training in both STEM and non-STEM disciplines. On the other hand, this finding might also highlight the lack of discipline specificity across RDM training, especially because only six articles specifically covered non-STEM subjects, keeping with previous findings that RDM training for researchers is lacking across the social sciences (Akers & Doty, 2013).

Findings of RDM

RDM Target Audience.

In terms of RDM audience, 29 (28.71%) were librarians, to be expected given that RDM focuses on those involved with academic research. Another 19 articles (18.81%) focused on faculty, 14 (13.86%) focused on graduate students, and 4 (3.96%) focused on undergraduate students. Additionally, 35 articles (34.66%) had a mixed-target audience (see Figure 4). These findings highlight the lack of RDM training for students and others preparing for
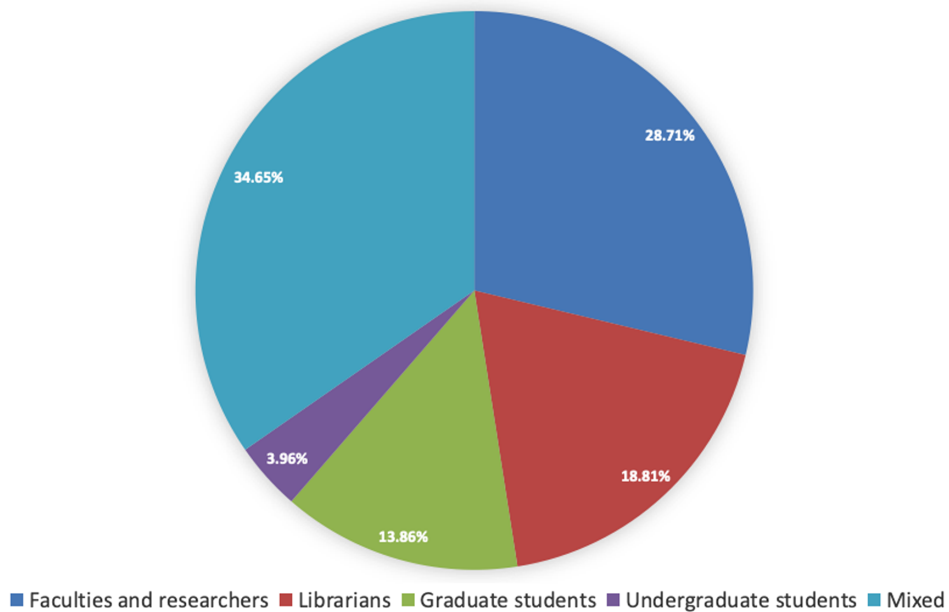

Figure 4. RDM Target Audience.

careers in research. As RDM grows in scope and importance, it will be essential to include students—future practitioners—along with faculty and researchers in RDM training much more than is currently the case.

RDM Aspects.

Among the 101 articles included, approximately 26.73% of these ($n = 27$) covered data sharing, including data curation, data preservation, and data repositories. Seven articles (6.93%) addressed data management plans. Four articles (3.96%) researched RDM tools and technologies, two articles (1.98%) researched data visualization and analysis, and one article studied data collections (0.99%). The remaining articles (59.41%, $n = 60$) studied mixed aspects of RDM (see Figure 5). A majority of the studies focus on data curation and data sharing (historically, a domain of library sciences), which suggests that library services might require additional bandwidth, resources, and skills to keep up with the data analysis and data-visualization expectations of researchers.

RDM Instruction

In the current scoping review, 49 articles included instructions on RDM (48.51%). In terms of the learning context, we found face-to-face instruction to be most common among the
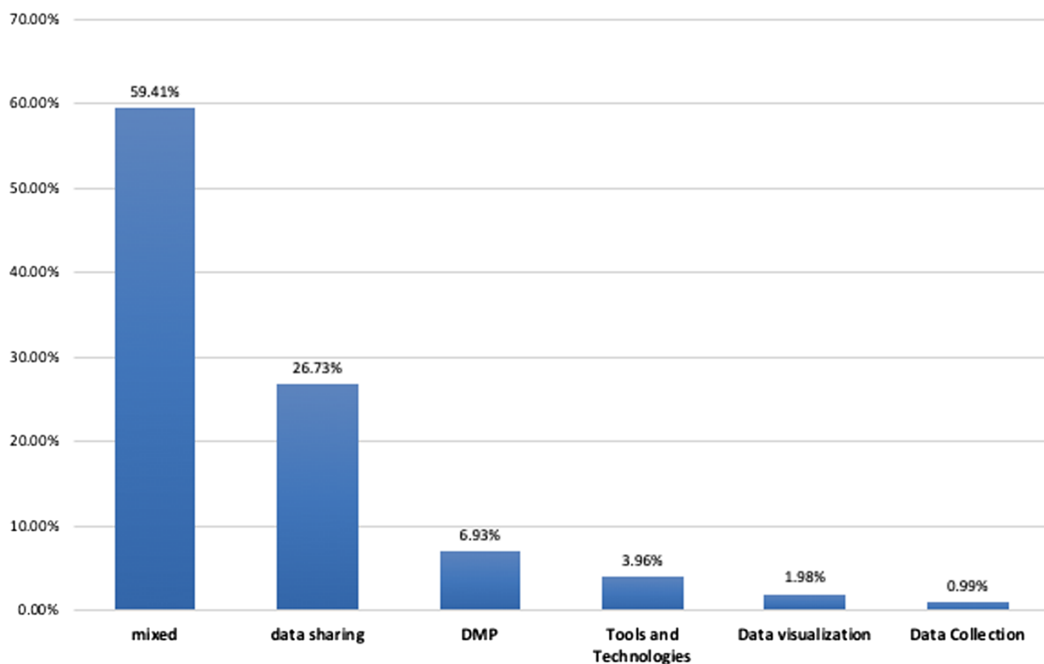

Figure 5. RDM Aspects.

49 included RDM instruction articles ($n = 20$, 40.82%), followed by the hybrid learning environment ($n = 7$, 14.29%) and online ($n = 5$, 10.20%). However, 17 of the 49 articles did not clearly specify the learning context (34.69%). The popularity of both online and hybrid teaching models has increased, and both online and traditional face-to-face teaching were found to have a positive impact on RDM skills. This research identified 12 articles that covered both online and hybrid formats, and we presume that this number will increase over time, especially under the context of global pandemic. Given this, it is important to note that each platform has advantages and disadvantages, and that numerous studies have found that online learning is not a good substitute for in-person learning (e.g., Condie & Livingston, 2007; Hannay & Newvine, 2006; Thorne, 2003; Xu et al., 2020). Therefore, the adaptation of RDM training to blended learning environments is suggested as a topic for future research.

Among the 49 studies about RDM instruction, 26.53% target audience of the RDM instruction was graduate students ($n = 13$), and 24.49% of those was librarians ($n = 12$), followed by faculty and researchers (8.16%, $n = 4$) and undergraduate students (6.12%, $n = 3$). An additional 17 studies were intended for a mixed-group audience (34.70%).

In terms of the providers of RDM instruction, 28 were librarians (57.14%), 6 were faculty members and researchers (12.25%), and 15 were a mixed group of providers (30.61%). More than half of the total instruction was provided by the librarians. Although we expected that some of these instructions are provided by subject librarians, we would still recommend more collaborations between librarians and researchers. This is because RDM is closely related to subjects; therefore, more RDM instruction provided collaboratively by librarians and faculty members/researchers in the discipline is needed.

The instruction format was also identified in the current scoping review. The results showed that 67.35% ($n = 33$) was offered through workshops, and 32.65% was offered in courses ($n = 16$). Additionally, among the 16 courses offered, 8 were on a credit basis, 2 did not offer credit, and the other 6 courses' credit information were not indicated. For the duration of the instruction, 63.27% was provided as a series ($n = 31$) such as courses, multi-part seminars and workshops, or as a one-time class, which accounted for 36.73% ($n = 18$) of the instruction. Unsurprisingly, workshops—the most common platform for library teaching and learning—made up more than 60% of the instruction offered. Whereas Matlatse et al. (2017) found that the workshop format excelled in increasing attendees' understanding and knowledge of RDM, they also found that it was less successful in increasing their perception of their RDM skills. This suggests that RDM proficiency is developed only over time and with practice, and that practitioners would benefit from learning more about how to integrate RDM into their professional activities both over the short and long terms.

Furthermore, we coded the RDM instruction topics for the 49 studies. Six (12.24%) stated that they provided instruction about RDM but did not specify what topics they covered in the instruction; these were coded as unspecified. Among the remaining 43 studies, most covered more than one topic. A total of 28 studies offered instructions about data sharing, 20 discussed data storage, 19 covered data management plans, 17 addressed data documentation, 14 covered RDM ethics, 9 covered data visualization and data analysis, 6 included RDM tools, and 6 provided instructions about data security. In addition, 27 studies stated that they provided an overview or introduction to RDM (see Table 2).

It is evident that the majority of training attempted to cover multiple topics of RDM. For example, Kafel et al. (2014) developed the New England Collaborative Data Management Curriculum, which included seven modules such as types, formats, and stages of data; contextual details needed to make data meaningful to others; data storage, backup, and security; data sharing and re-use policies; and so on. Some workshops or seminars target a specific data management field. For instance, Henshaw & Meinke (2018) discussed the integration of data analysis into subject-based courses, with a focus on data analysis and visualization.

Also noteworthy is that a large number of training programs provided an introduction to RDM or an RDM overview (27 out of 49, 55.10%). Although RDM is still an emergent research field, this might also be connected to the fact that librarians conduct more than half of RDM training (57.14%). More specific and more disciplined-based RDM training might require more in-depth disciplinary knowledge and will require more collaboration between librarians and researchers. The studies analyzed here included some successful models. For instance, Holles and Schmidt (2018) developed and co-taught an RDM graduate

RDM topics covered by the instruction	*n*
Data sharing	28
RDM overview	27
Data storage	20
DMP	19
Data documentation	17
RDM ethics	14
Data visualization & analysis	9
Data security	6
RDM tools	6
Unspecified	6

Table 2. RDM Instruction Topics.

course that gave students the broad conceptual framework of RDM as well as its application to a specific research project. In addition, Searle (2015) described the development and implementation of scenario-based group-learning activities through a collaboration of subject librarians, learning advisors, and IT helpdesk team members. These examples reflect the collaborative and cross-disciplinary nature of successful RDM applications.

Of the 49 studies, we also identified 42 that examined the effect of RDM instruction, with 97.62% finding positive effects ($n = 41$) and one finding mixed effects (2.38%). The present study also documented the researchers' approaches to analyzing the effect of RDM. A total of 7 of the 42 studies (16.67%) provided a quantitative evaluation, and 21 (50.00%) used a qualitative evaluation. The other 14 studies (33.33%) used mixed approaches to investigate the effects of RDM instruction. Of all the studies that evaluated the effect of RDM instruction, however, only four out of forty-two (9.52%) used statistical analysis. This finding reveals a gap in the number of quantitative studies (especially those using statistical analysis) on the effects of RDM interventions. Reducing this gap is important given that quantitative studies provide robust assessments of the causal effects of interventions (Gillies et al., 2016).

CONCLUSION AND FUTURE RESEARCH

Contributions of the Current Study

Services pertaining to RDM have become prominent in academic libraries (Hey & Hey 2006; Pryor et al., 2013). However, few studies have systematically and comprehensively investigated the practice and effect of such training in academic libraries. The current study developed systematic database searches to locate potential articles and designed a detailed and systematic coding scheme to examine the substantive features of RDM and characteristics of RDM practice, with an emphasis on RDM training. This study thereby contributes to our comprehensive understanding of some essential elements associated with RDM training.

The current study found that demand for RDM training increased significantly after 2011. Furthermore, research about RDM training spread across countries and continents including North America, Europe, and Asia Pacific countries. The findings from the present study proved that RDM training is essential for both STEM and non-STEM subjects, but simultaneously indicated that non-STEM subjects such as the social sciences lack this training, which is consistent with the previous literature (Akers & Doty, 2013).

The findings of the current study pointed to some future directions for researchers in the RDM field. Among the most pressing is the movement toward online and blended education across all age cohorts in response to COVID-19. The current study identified 12 studies

employing blended-learning formats to deliver RDM instruction in academic libraries. This finding helps consolidate the body of knowledge regarding RDM to date while also pinpointing gaps in the literature that could generate ideas for additional research.

Limitation of the Study and Future Directions

This current scoping review focused on the peer-reviewed journal articles and conference papers identified in the literature about RDM in academic libraries. However, a literature review of what has been formally published only reflects what has been written about in the academic literature. Furthermore, the practical nature of RDM training lends itself naturally to reports, blogs, and other forms of informal correspondence such as university websites. Therefore, we admit that a more accurate review of the state of RDM practice would be gleaned from other more broad and informal sources. Future studies could explore more in RDM practice and include reports, blogs, and other forms of informal sources to obtain a more accurate and comprehensive picture of RDM practice. RDM is a broad and in-depth concept involving various activities throughout the research data lifecycle, revealing the need for future literature reviews on RDM services in a more comprehensive scenario. As we acknowledged, the current study was structured as a scoping review and thus might have inadvertently omitted relevant research, and we also used data found in specific databases and other sources in the 2010 to 2020 timeframe, which might be significantly different from that gathered from other sources and covering other years.

Results from the current literature also demonstrated that a large number of RDM training programs focus on introducing RDM or giving an overview of RDM, thus pointing out the lack of in-depth and discipline-based curriculum for researchers across domains. Future practitioners could collaborate more with the faculty or researchers to develop more discipline-based curriculums for RDM and more application-based approaches to teach RDM.

Additionally, this present study also identified the lack of quantitative studies, especially statistical analysis, on the effect of RDM interventions in the RDM research. However, the previous literature indicated that quantitative approaches provide robust evaluative evidence about intervention choices (Gillies et al., 2016), which is critical for empirical studies. Future researchers in the RDM field should consider employing more quantitative methods to measure the effectiveness of these interventions.

STATEMENT ON CONFLICTS OF INTEREST

We declare that we have no conflicts of interest.

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Appendix A

SEARCH TERMS

((DE "DATA management" OR DE "DATA curation") OR TI ("Data management" OR "research data" OR "Data literacy" OR "data curation" OR "data preservation" OR "data repository") OR AB ("Data management" OR "research data" OR "Data literacy" OR "data curation" OR "data preservation" OR "data repository")) AND (TI (train* OR "boot camp" OR workshop* OR program OR educat* OR "professional development" OR "flipped classroom" OR tutorial OR class* OR consult* OR teach*) OR AB (train* OR "boot camp" OR workshop* OR program OR educat* OR "professional development" OR "flipped classroom" OR tutorial OR class* OR consult* OR teach*))

Appendix B

QUALITY ASSESSMENT

Methodological Quality Questionnaire Score Summary for Empirical Studies

Criteria	Yes (2)	Partial (1)	No (0)	Score
1 Theoretical or Conceptual Definition				
2 State of problem and Research Question/Hypothesis				
3 Research Design				
4 Sample				
5 Data Analysis				
6 Results reported				
7 Evaluation of the findings				
8 Implications for Practitioners				
Total				

Methodological Quality Questionnaire Score Summary for Best Practices

Criteria	Yes (2)	Partial (1)	No (0)	Score
1 Theoretical or Conceptual Definition				
2 State of problem				
3 stakeholders of the practice				
4 Description of the procedure in detail				
5 Evaluation of the practice (either subjectively or objectively, but assign zero if it only has a brief self-reflection on the practice)				
Total				