Data competencies for liaison librarians: A scoping review

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Abstract

This retrospective scoping review explores the data-related competencies required by liaison and subject librarians to effectively support academic researchers. Despite the growing demand for research data assistance, many librarians lack formal training (Tenopir et al., 2014) or confidence (Cox et al., 2012) in this area, often relying on self-taught skills. The objective of this review was to map data-related competencies over a ten-year period (2012-2022) with particular attention given to the skill sets that liaisons or non-data librarians may need to develop or hone. Overall, the findings indicate a surprisingly stable list of skills over this period. This review finds that to support research data services on campus, librarians must rely on traditional skills including reference/consulting, teaching/training and collaboration/engagement as well as data-specific competencies, including metadata creation, data preparation for repositories, data preservation, data management plan (DMP) creation, and programming/data analysis. These competencies are essential for librarians to assist researchers with data queries. The study highlights the need for structured training and suggests which competencies to prioritize. The findings aim to guide the development of self-training resources and cross-training initiatives to better equip librarians in supporting data-rich research.

Keywords

Data, Liaison Librarians, Skills, Competencies, Research Data Support, Training

Introduction

In 2012, Tenopir, Birch and Allard published the ACRL White Paper 'Academic Libraries and Research Data Services: Current Practices and Plans for the Future.' Their proposition was that as science becomes more 'collaborative, data intensive, and computational,' (Tenopir et al., 2012) researchers would have greater data management needs. The White Paper cited the National Science Foundation's 'Plan for Open Government' (National Science Foundation, 2012) which required data management plans for all funded research projects. It stated, 'It is critical that research data, regardless of the funding source, be properly managed, curated, standardized, citable, easily shared and made discoverable by others.'

The 2013 Holdren memorandum on 'Increasing Access to the Results of Federally Funded Scientific Research' required public access to research results and data (Whitehouse Office of Science and Technology Policy (OSTP), 2013). It directs Federal agencies, such as the NIH and NSF, to develop plans to support public access to the results of research, including data, funded by the Federal Government.

Given the changes in the way science was being conducted and analyzed, and the requirements for sharing of research results, college and university campuses were required to support data

management activities in ways not previously done. These changes combined with the ACRL White Paper, impelled academic libraries to help researchers fill these data management skill gaps.

In 2011, librarians at Purdue undertook a project to understand what data management skills researchers had, and what skills they needed via an IMLS grant to study 'Data Information Literacies' (Institute of Museum and Library Services, 2011). Purdue University Libraries partnered with the University of Minnesota Libraries, the University of Oregon Libraries, and Cornell University Libraries to develop and implement data information literacy instruction for graduate students. An objective of this research was the development of instructional curricula as well as a community of trained librarians and disciplinary researchers who would share their skills with their institutions and local colleagues in a 'train the trainer' model (Carlson, 2011).

A product of this grant-funded research was the book 'Data Information Literacies: Librarians, Data, and the Education of a New Generation of Researchers' (Carlson & Johnston, 2015). This book guides librarians to teach data-related skills to researchers at their university. The focus is on researcher needs, but as a by-product of librarians leading these instructional sessions, librarians would also acquire and become proficient in these data-related skills.

At about the same time, librarians in the UK formed responses to research data-related questions. Rice et al. wrote an article on a pilot course on Research Data Management (RDM) that data librarians led at the University of Edinburgh in 2012-2013 for librarians (Rice et al., 2013). This course was based on MANTRA, a course developed by the EDINA and Data Library, University of Edinburgh, for early career researchers (University of Edinburgh, n.d.).

In 2011, in the Netherlands, 3TU.Datacentrum developed the course 'Data Intelligence 4 Librarians' to provide online resources and training for digital preservation practitioners, specifically for library staff (De Smaele et al., 2013). The site is now called 'Essentials 4 Data Support.' It is an introductory course for those interested in supporting researchers in various data management activities including storing, managing, archiving, and sharing their research data (Research Data Netherlands, n.d.).

In 2016, Rice and Southall published 'The Data Librarian's Handbook' which outlines how librarians can work with researchers in a case study format (Rice & Southall, 2016). This book, together with 'Databrarianship: The Academic Data Librarian in Theory and Practice' edited by Kellam and Thompson, describes the breadth of data-related activities taking place in libraries, and how librarians and data professionals support research in an academic institution (Kellam & Thompson, 2016).

The Digital Curation Centre (DCC) was created in 2004 by a consortium comprising the Universities of Edinburgh and Glasgow, UKOLN at the University of Bath, and STFC, which managed the Rutherford Appleton and Daresbury Laboratories. Its mission was to solve challenges in digital curation that could not be tackled by any single institution or discipline. To that end, they developed models of research support (Pryor, 2009), how-to-guides, and self-learning modules (Digital Curation Centre, n.d.). In 2015, the Data Curation Network (DCN) began in the U.S. as a grant-funded organization of institutional repositories and non-profit institutions whose vision was to advance open research by making data more ethical, reusable, and understandable. They also host primers and online modules (Blake et al., 2022).

The focus on data instruction and librarian learning led to the development of the Association of College and Research Libraries Research Data Management Road Show in the United States. The Road Show demonstrated how librarians might adapt their pre-existing information literacy skills to more specific research data management skills. For example, if a librarian is comfortable with reference interviewing, they could use that skill to have a consultation about the research process and data

needs (Goben & Sapp Nelson, 2024). Road Show attendees were shown a chart with a scaffolded learning plan to develop RDM-specific knowledge (Goben & Sapp Nelson, 2018).

There has been a recent effort to create librarian positions focused solely on data, such as the data librarian or data specialist. Some libraries even host entire departments that serve the data needs on campus. This practice has been concentrated at larger universities. Researchers at smaller institutions still require help with data, but their needs are met by other librarian roles, such as liaisons or research and instruction librarians or scholarly communications librarians or other departments (Tenopir et al., 2019).

Data and the sharing of data is a relatively new venture for librarians. There are courses on these topics in Schools of Information, but these classes are not required, so many aspiring librarians do not take them. Many librarians who support research data are self-taught (Thomas & Urban, 2018). 'Working with research data' does not usually top the list of skills or experiences in a subject or liaison librarian's job description. Increasingly though, researchers seek help in creating data management plans, identifying and preparing data to deposit in an appropriate repository, and creating metadata. Academic librarians who may be unfamiliar with research data may find these requests overwhelming (Fuhr, 2022).

There are many places to find training, including self-paced online training, offered by MANTRA and the Digital Curation Center. Conferences with data-related sessions often offer workshops and instruction. However, it can be difficult to understand the breadth of the skills needed from the beginning to the end of a research project and beyond the project's conclusion. In addition, the content of these discipline-agnostic introductory workshops may not meet the specific demands of scholars.

Objectives

Liaison librarians have helped researchers find and access data as part of traditional reference and consultation work for many years. Tenopir et al. cite subject-based librarians as providing 61% of the 'research data reference/consultation/instruction services to researchers' (2015). This scoping review is intended as a comprehensive look at empirical literature to understand the data skills needed by liaison librarians in supporting data-rich research projects, from the basics of data literacy through data preservation. We wanted to look at what has happened in the past, how this has changed over time, and if there were points of consensus. We aimed to gather studies that reported data competencies for an audience of academic librarians collected through empirical methods. The primary research questions are:

- RQ1 What does the literature indicate are the data-related competencies/skills that non-data liaison librarians (including reference, instruction, subject, and teaching librarians) should have to support researchers?
- RQ2 What are the trends over this ten-year period in the literature related to data competencies?

We use the word *competencies*, as defined by the National Institutes of Health, to mean 'the knowledge, skills, abilities, and behaviors that contribute to individual and organizational performance' (National Institutes of Health, 2024). By combining competencies with the word data, we mean using the knowledge, skills, abilities, and behaviors to support researchers in their work with data.

Other studies that list data competencies

Data competency skill lists are cited in the library and information science literature with regards to librarians teaching researchers what they need to know. Qin and D'Ignazio discussed data-related skills as 'science data literacy,' differentiating it from information literacy and digital literacy. Their efforts were around educating undergraduate and graduate STEM students (Calzada Prado & Marzal, 2013). Carlson, et al. generated a list of 'Core Competencies for Data Information Literacy' for students and faculty, including some of the same skills that Qin and D'Ignazio identified (2011). The Carlson article suggested that librarians should 'map the skill sets librarians currently have to the data information literacy objectives, either as stated here [in that article] or as they develop in practice.' Piorun linked learning objectives to the NSF's Data Management Plan requirements. Piorun's article described a training program geared towards medical, graduate, and undergraduate science students (Piorun et al., 2012). The authors parsed learning objectives into modules that could be taught to researchers at different levels. Prado and Marzal described Data literacy as having ties to Information literacy and several other frameworks. In their article, they define and describe the competencies so that they could be separated into training modules (Calzada Prado & Marzal, 2013). Schneider combined the information literacy skills, and the Digital Preservation Outreach & Education (DPOE) curriculum from the Library of Congress for undergraduates, graduate students, LIS (Library and Information Science) students, data creators, data scientists, data librarians and data managers. The approach is user-oriented and includes guidance on which competencies should be taught to each group (Schneider, 2013). Some of the competencies are not well defined, i.e., 'Extracting Information from Data Models (and people).'

Pothier and Condon developed Business Data Literacy Competencies for business school students, in accordance with the needs of corporate institutions, having found the previously published data competencies more focused on the sciences (Pothier & Condon, 2020). Risdale, et al., examined data competencies that were reported on in the research literature, and counted them to surface the best of the best (Risdale et al., n.d.). They came up with 22 competencies in five different categories. However, the approach was not focused on librarian training or upskilling librarians.

Sapp Nelson created a matrix of data management competencies that include learning goals (Sapp Nelson, 2017). She scaffolded it such that a researcher could start from an undergraduate level and learn to manage data through doctorate-level work and data stewardship. The skills build as one moves from personal information management through team data management, to research enterprise management. The competencies include observable activities that illustrate, through Bloom's taxonomy (cognitive, psychomotor and affective), whether the competency has been achieved. The thirty-six competencies identified in the matrix are similar to the ones we identified and used in our review. However, our purpose was to track what *librarians* need training on, so there are differences.

We chose a scoping review methodology to assess these questions because we wanted to identify and track developments in the literature over the ten years following Tenopir's seminal white paper 'Academic Libraries and Research Data Services' published by ACRL in 2012 (Tenopir et al., 2012). We wanted to identify if there were any trends related to the data competencies and to see if there was consensus in the skills librarians felt they needed to support data-related research.

This white paper reported on a survey of ARL Libraries about the data-related services they were providing or planned to provide. Tenopir et al., categorized the skills into 'Informational/Consultative Research Data Services (RDS)' and 'Technical Assistance/Hands-On Research Data Services.' This work provided us with an initial framework to examine the literature, but it needed to be enlarged and updated. We built on the skills/competencies through a careful reading of what we found in the

literature and devised four categories of competencies including data literacy, data management, data curation, and tools/technology/software.

Methods

We used a scoping review methodology to identify articles. We developed the search strategy by brainstorming relevant keywords and term harvesting from known research in the Library Information Science & Technology Abstracts (LISTA) database. The strategy was then tested against known relevant articles. Several standardized vocabularies were evaluated, and we determined that adding specific vocabulary terms would not add relevant articles to the results. The search strategy used in LISTA (EBSCO) with *all fields* being searched was: (("data literac*" OR "data manag*" OR "data curat*" OR "data visualization" OR "research data")) AND ((libraries OR library OR librarian OR "information professional" OR archivist)) AND ((training OR education OR school OR "continuing education" OR course* OR class* OR skill* OR competenc* OR standard*)) DATE LIMIT: 2012-2022. No further limits were included in the strategy. The strategy can be further visualized in Table 1.

The search was run in the following databases: Academic Search Complete, ERIC, Information Science & Technology Abstracts (ISTA), Library & Information Science Source, plus Dissertations & Theses Global (ProQuest interface), and Web of Science: Core Collection. The first four database searches were conducted using the EBSCO interface. The searches were all run on March 29, 2022. The choice of which databases to query was influenced by institutional availability, however the authors deemed the available databases to be of sufficient depth. The number of databases included achieved broad interdisciplinary coverage. The Prisma diagram documenting the search numbers and exclusion decisions can be found in Figure 1. Supplemental searching included Google Scholar and hand-searching the *Journal of eScience Librarianship*. The authors chose to hand-search the *Journal of eScience Librarianship* due to lack of indexing. Only the first 200 Google Scholar results from a simplified search were examined. These results were included in the deduplication and screening and are represented as a database in the Prisma chart.

Term Categories	Data-related terms	Librarian-related terms	Competency-related terms
Term Lists	data literac* data manag* data curat* data visualization research data	libraries library librarian information professional archivist	training education school continuing education course* class* skill* competenc* standard*

Table 1. Search terms developed and used in the search strategy (originally for LISTA)
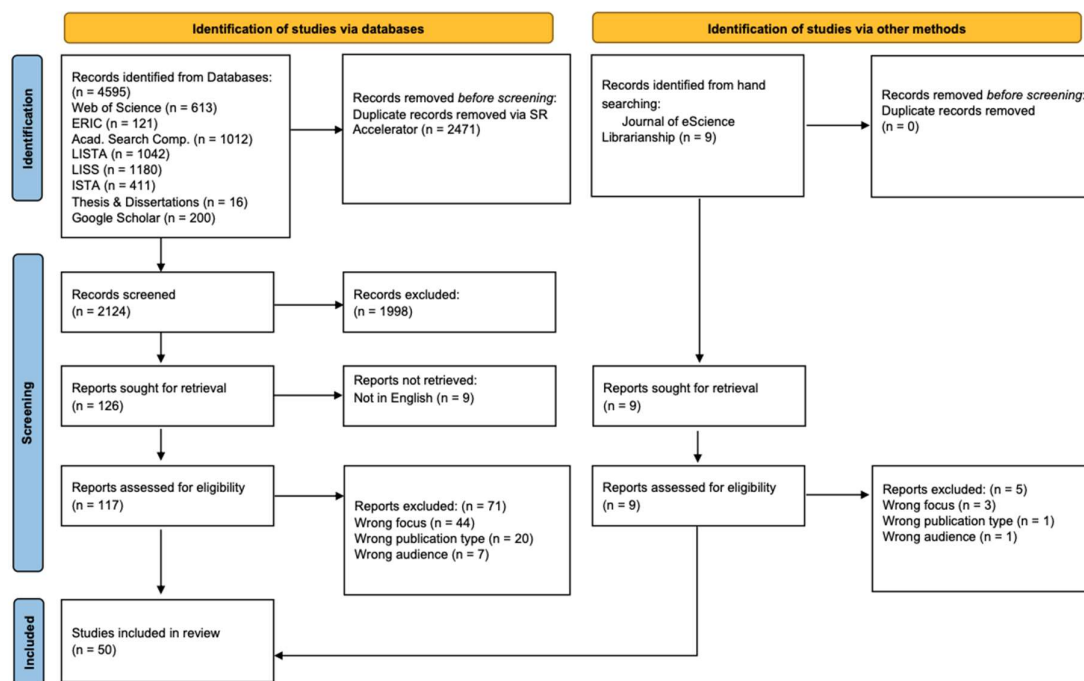
Figure 1. Prisma Flow Diagram

Eligibility criteria & first round screening

This review screened for articles that met the following inclusion criteria:

1. The article must present information concerning skill development, current knowledge or present an assessment/survey based on expanding librarian roles to include data.
2. The population must be librarians/information professionals working in a library. This group must work in a setting where they support the learning and/or research of faculty/students regardless of discipline.
3. The target setting must include higher education.
4. Sources must report original research.

These criteria were developed to suit our study objectives. The first criterion is the core of what we wanted to study. It's broad enough to be inclusive of multiple study designs. The second is an important distinction because it centers the conversation on librarians. Many studies were excluded because they discussed data competency assessment following a session aimed at student learning. The fourth criterion was designed to cast a broad net over types of research. We commonly see peer reviewed literature used as inclusion criteria; however, we decided instead to focus on original research.

Primary deduplication occurred using the Deduplicator tool available through SR Accelerator. A small number of additional duplicates were identified and removed during the subsequent title and abstract screening. All deduplication is accounted for in the Prisma chart. Title and abstract screening was performed using the web-based tool, Rayyan. A pilot screening round of 100 randomly selected records was performed to ensure consistency in the application of predefined inclusion and exclusion criteria. Table 2 outlines and defines our inclusion and exclusion criteria, including examples of when a study would be excluded. We utilized Rayyan's blind feature and resolved disagreements through

discussion and scope clarification. After we ran the pilot screening round, the blind feature was again used for the first round of screening. All results were independently assessed by both authors.

We resolved discrepancies through discussion. Articles that one or both of us deemed 'maybe' were included. The *maybe* category contained research that lacked an abstract or the title/abstract did not include enough context to exclude without reading the full text. Ultimately, we excluded 2,007 articles, leaving 126 articles for the second-round screening.

Criteria Category	Definition	Code (Rayyan label)
Inclusion		
	The article must focus on skill development, current knowledge of librarians or present as assessment/survey based on expanding librarian roles to include data.	Right_focus
	The target population must be librarians/information professionals. This group must work in a setting where they support the learning and/or research of faculty/students regardless of discipline.	Right_audience
	The target setting must include higher education.	Right_setting
	Sources must report on original research.	Right_publication type
Exclusion		
	The article does not focus on skill development, knowledge of librarians or assessment/survey based on expanding librarian roles to include data.	Wrong_focus
	Non-librarian learning focus. This might include presentation of a data literacy training program developed for students or for a department.	Wrong_audience
	Non-academic library setting: primary & secondary school, special libraries, corporate libraries, public libraries. (**Exception:** a health library that is serving a medical school.)	Wrong_setting
	Review articles, overviews or opinion pieces that did not present original research	Wrong_publication_type

Table 2. Inclusion and Exclusion Criteria

Second round screening

Proceeding to the second round, we exported the 126 results from Rayyan and added 4 articles found in hand-searching to begin our second round of screening. We followed the same discrepancy resolution as reported in the first round.

Exclusion

We decided not to translate articles that were not in English due to a lack of funds. This decision accounted for the exclusion of nine articles in Portuguese, German, Bosnian, Chinese, and Spanish.

This brought us to 117 articles and research papers. From there, we excluded articles that we categorized as *Wrong focus* (42). This included research that did not focus on data competencies or had an Information School focus. We also eliminated those items of the *Wrong publication type* (20). In general, these publications included review articles, overviews, or pieces that did not present original research. Last, we excluded research for the *Wrong audience* (7), which meant any audience not composed of academic, medical school librarians, or library staff. These decisions were established at the outset of the project to maintain a narrow focus with comparable competencies across articles.

Final studies

Once we added in 4 studies from hand searching we narrowed our results to 50 studies and coded these articles to understand which data competencies were identified as the ones that librarians should have. These studies are detailed in Table 3.

Author(s)	Year	Title	Journal	Study Method	Purpose	Location
Tenopir et al.	2012	Academic libraries and research data services: Current practices and plans for the future.	*ALA White Papers & Reports*	Survey	Assess types of RDM support, planning, and staffing	USA, CAN
Cox et al.	2012	Upskilling liaison librarians for research data management.	*Ariadne*	Report	Connects RDM to traditional library roles and presents training	UK
Reznik-Zellen et al.	2012	Tiers of research data support services.	*Journal of eScience Librarianship*	Environmental scan	Develops tiers of RDM support: education, consultation and infrastructure	USA
Creamer et al.	2012	An assessment of needed competencies to promote the data curation and data management librarianship of health sciences and science and technology librarians in New England.	*Journal of eScience Librarianship*	Survey	Assess needed librarian competencies	USA
Si et al.	2013	The cultivation of scientific data specialists: Development of LIS education oriented to e-science service requirements.	*Library Hi Tech*	Content analysis	Analyze data-related job ads and correlate iSchool curricula	Multiple
Charbonneau	2013	Strategies for data management engagement.	*Medical Reference Services Quarterly*	Report	Describes data-related opportunities for health sciences engagement	USA
Corrall et al.	2013	Bibliometrics and research data management services: Emerging trends in library support for research.	*Library Trends*	Survey	Investigate service developments including staff training needs, audiences and constraints	AUS, NZ, IRL, UK
Stewart & Crossley	2013	Library readiness for research data management.	*ALISS Quarterly*	Report	Investigate what knowledge areas librarians need to support RDM	UK
Antell et al.	2014	Dealing with data: Science librarians' participation in data management at Association of Research Libraries institutions.	*College & Research Libraries*	Survey	Assess awareness and involvement of science librarians in RDM-related activities	USA
Xia & Wang	2014	Competencies and responsibilities of social science data librarians: An analysis of job descriptions.	*College & Research Libraries*	Mixed Methods	Assess position adds in order to clarify qualifications sought	AUS, CAN, GER, IRL, NED, QA, SG, SWE, UK, UAE, USA
Tenopir et al.	2014	Research data management services in academic research libraries and perceptions of librarians.	*Library & Information Science Research*	Survey	Compare RDM activity frequency with library policy	USA, CAN
Lee & Stvilia	2014	Data curation practices in institutional repositories: An exploratory study.	*Proceedings of the Association for Information Science & Technology*	Survey	Assess data curation practices in institutional repositories.	USA
Cox et al.	2014	A spider, an octopus, or an animal just coming into existence? Designing a curriculum for librarians to support research data management.	*Journal of eScience Librarianship*	Mixed methods	Introduces, explains and discusses assessment of RDM Rose (training for librarians)	UK
Brown et al.	2015	Developing new skills for research support librarians.	*Australian Library Journal*	Case Study	Offers perspective of academic librarians moving to a data librarian role	AUS
Davis & Cross	2015	Using a data management plan review service as a training ground for librarians.	*Journal of Librarianship & Scholarly Communication*	Report	Evaluates a (DMP review) librarian training program based on pre-defined competencies	USA
Johnson & Bresnahan	2015	DataDay! Designing and assessing a research data workshop for subject librarians.	*Journal of Librarianship and Scholarly Communication*	Report	Describes a liaison training day and post training assessment	USA
Lockhart & Leiß	2015	Librarians' skills for e-research support–joint project at TU München and CPUT.	*Proceedings of the IATUL Conferences. Paper 2.*	Case Study	Librarians developed list of RDM services and determined required skills to offer services	GER, SA

Dér	2015	Exploring the academic libraries' readiness for research data management: Cases from Hungary and Estonia.	*Master's Thesis*	Case Study	Understand library staff member opinions on roles in RDM and institutional practice	HU, EE
Cross et al.	2015	Where do we go from here: Choosing a framework for assessing research data services and training.	*Charleston Conference (2015)*	Report	Evaluates existing frameworks for assessment of RDM	USA
Tammaro et al.	2016	Understanding roles and responsibilities of data curators: An international perspective.	*Libellarium: Journal for the Research of Writing, Books, and Cultural Heritage Institutions*	Mixed Methods	Chart key tasks and responsibilities of data curators	IT, CH, USA
Tenopir et al.	2017	Research data services in European and North American libraries: Current offerings and plans for the future.	*Proceedings of the Association for Information Science & Technology*	Survey	Establishes RDM services and goals by surveying directors, including staff skill development	EU
Lee & Stvilia.	2017	Practices of research data curation in institutional repositories: A qualitative view from repository staff.	*PLoS ONE*	Survey	Defines current IR practices through interviews at 13 research universities	USA
Southall, & Scutt	2017	Training for research data management at the Bodleian Libraries: National contexts and local implementation for researchers and librarians.	*New Review of Academic Librarianship*	Report	Describes RDM training and development at a library	UK
Johnston et al.	2017	Results of the Fall 2016 data curation pilot.	*University Digital Conservancy*	Mixed Methods	Develops a multi-institutional staffing model for data curation services	USA
Kaushik	2017	Perceptions of LIS professionals about data curation.	*World Digital Libraries*	Survey	Identifies views of LIS professionals on data curation activities	IN
Federer	2018	Defining data librarianship: A survey of competencies, skills, and training.	*Journal of the Medical Library Association*	Survey	Describes data librarianship skills and tasks	USA
Goben & Sapp Nelson	2018	The data engagement opportunities scaffold: Development and implementation.	*Journal of eScience Librarianship*	Report	Presents a Data Engagement Opportunities Scaffold that merge LIS skills with RDM and provide measurable outcomes	USA
Read et al.	2019	A two-tiered curriculum to improve data management practices for researchers.	*PLoS ONE*	Mixed methods	Librarians took online modules with embedded questions to track changes in understanding	USA
Eclevia et al.	2019	What makes a data librarian: An analysis of job descriptions and specifications for data librarian.	*Qualitative & Quantitative Methods in Libraries*	Job Ad Analysis	Presents analysis of data librarian job postings	USA, CAN, UK, SG
Ohaji et al.	2019	The role of a data librarian in academic and research libraries.	*Information Research*	Interview	Presents a "blueprint" mapping the development of the data librarian role based on interviews	NZ
Tammaro et al.	2019	Data curator's roles and responsibilities: An international perspective.	*Libri: International Journal of Libraries & Information Services*	Mixed Methods	Defines data curation through a multi-year investigation, including interviews and job posting analyses	Multiple
Li et al.	2019	Research data management: What can librarians really help?	*The Grey Journal (TGJ)*	Case Study	Describes developing RDM services at one institution	USA
Cox et al.	2019	Maturing research data services and the transformation of academic libraries.	*Journal of Documentation*	Survey	Identifies changes from 2019 to 2014 questionnaires to analyze changes RDM in libraries	AUS, CAN, GER, IRL, NED, NZ, UK, USA
Tang & Hu	2019	Providing research data management (RDM) services in libraries: Preparedness, roles, challenges, and training for RDM Practice.	*Data & Information Management*	Survey	Presents results of a survey including questions on roles, readiness for RDM, and challenges	AUS, ET, FI, FR, HU, JPN, KG, NZ, NOR, SA, RS, SG, SA,

						ES, CH, TH, TT, TR, UG, ZM, ZW, CAN, UK, NED, IN, JM, GER, UAE, USA
Federer & Qin	2019	Beyond the data management plan: Expanding roles for librarians in data science and open science.	*Proceedings of the Association for Information Science & Technology*	Mixed Methods	Understand future development needs in RDM and open science	USA
Tenopir et al.	2019	Academic librarians and research data services: Attitudes and practices.	*ITlib: Informacne Technologie a Kniznice*	Survey	Presents results of a survey assessing perceived importance, confidence, and contribution of librarians to RDS	USA, CAN
Rice	2019	Supporting research data management and open science in academic libraries: A data librarian's view.	*Mitteilungen Der Vereinigung Österreichischer Bibliothekarinnen Und Bibliothekare*	Case Study	Discusses one institution's path to developing RDM	SCT
Joo et al.	2019	Librarians' perceptions on skills/knowledge and resources needed for research data services: Preliminary results.	*JCDL '19: Proceedings of the 18th Joint Conference on Digital Libraries*	Survey	The survey assesses librarian opinions surrounding the importance of skill sets as they relate to RDS	USA
Chawinga & Zinn	2020	Research data management at an African medical university: Implications for academic librarianship.	*Journal of Academic Librarianship*	Mixed Methods	Assesses the RDM landscape and reveals an opportunity for libraries to step in	SA
Ahmad et al.	2020	Librarian's perspective for the implementation of big data analytics in libraries on the basis of lean-startup model.	*Digital Library Perspectives*	Survey	Questionnaire responses develop a path to big data analytics services in libraries	PK
Chiware	2020	Data librarianship in South African academic and research libraries: a survey.	*Library Management*	Mixed Methods	Define current competencies of practicing RDS librarians in South Africa	SA
Federer et al.	2020	Developing the librarian workforce for data science and open science.	*Libellarium: Journal for the Research of Writing, Books, and Cultural Heritage Institutions*	Report	Report of a workshop to define skills needed for data and open science librarians	USA
Ducas et al.	2020	Reinventing ourselves: New and emerging roles of academic librarians in Canadian research-intensive universities.	*College & Research Libraries*	Survey	Discusses new roles in librarianship and the related skills required and confidence level	CAN
Bishop et al.	2021	Job analyses of earth science data librarians and data managers.	*Bulletin of the American Meteorological Society*	Interview	Present the skills of practicing librarians and data managers	USA
Masinde et al.	2021	Research librarians' experiences of research data management activities at an academic library in a developing country.	*Data and Information Management*	Interview	Presents the skills related to RDM activities with aims to support growing curation needs	KE
Ashiq et al.	2021	The perception of library and information science (LIS) professionals about research data management services in university libraries of Pakistan.	*Libri: International Journal of Libraries & Information Services*	Survey	Addresses LIS professional opinions regarding RDM training needs and reasons for RDM support	PK
Joo & Schmidt	2021	Research data services from the perspective of academic librarians.	*Digital Library Perspectives*	Survey	Presents survey results investigating librarian perceptions of RDS in libraries	USA

Kvale	2021	Using personas to visualize the need for data stewardship.	*College & Research Libraries*	Mixed Methods	Explores possibilities of research data stewards to identify skills required of such a role	NOR
Borkakoti & Singh	2021	Research data management in central universities and institutes of national importance: A perspective from Northeast India.	*Library Philosophy & Practice*	Survey	Discover opinions of current LIS professionals regarding RDM	IN
Fuhr	2022	Developing data services skills in academic libraries.	*College & Research Libraries*	Survey	Assess current competencies and preferred mechanisms for upskilling	CAN, USA, UK, AUS

Table 3. Final Studies

Coding for competencies

During our second round of screening, we tested a preliminary collection of codes. Shared coding was completed in Excel with each competency represented by a column and each article represented by a row. The Excel sheet produced a series of binary codes indicating whether the work included the identified competency. Both authors examined each of the articles for inclusion/exclusion criteria and a trial round of coding was completed. The authors discussed discrepancies until an agreement was reached. The authors developed a formalized codebook and definitions based on the competency-based content identified in the articles. Each author re-coded half the articles based on the updated competency-based coding sheet. The codebook is available via the Open Science Framework repository here: https://osf.io/qa5vr/.

The competency list is in Table 4. During our work, we identified two larger themes among our categories: Previously held liaison librarian competency areas and competency areas that represent data-specific skills.

Themes	Liaison Librarian Competencies	Data-Specific Competencies			
Categories	Consultative/ Informational	Data Literacy	Data Management	Data Curation	Tools/Tech/ Software
Competencies	Reference & Consulting & Communication Teaching & Training Collaboration & Library Engagement & Outreach Understand Research Methodologies Disciplinary Background	Find Data Access Data Cite Data Use Data Ethically Data Acquisition or Deaccession Research Data Lifecycle Author & document identifiers Bibliometrics Promote Open Science	Data Project Planning DMP Creation Data Documentation Funder Mandate Familiarity Copyright & License Confidentiality Repository Selection	Repository Use Determine Data Quality Data Security Data Preservation Data Storage Metadata Prepare Data for Sharing Data Governance IR Creation & Management Support Multiple Data Types	Data Cleaning Data Visualization Programming Data Analysis Statistical Analysis Tech Infrastructure IT Competency

Table 4. Themes, categories, and competencies used in coding the included articles

Table 4 shows the classification of each of the competencies. Ten of the skills fall into the Data Curation category. Data Curation is very important, as open data becomes mandatory as a condition of federal funding. It's also an area that is well documented, due to organizations such as the Data Curation Network and the Digital Curation Centre who provide guidance and training. The next area of expertise falls into the Data Literacy category, which addresses nine more straightforward skills, such as finding data and data citation. Data Management contains nine skills, which are important as researchers begin working with data. They need to understand how to document their data processes and choose a repository for long-term storage in accordance with funder specifications. The Tools/Tech/Software category contains seven skills. Often expert researchers have familiarity with the tools they need to do their work, but obtaining access to those tools, or finding where to get help, can facilitate their work.

Results

Highlights of the results are the top ten data competencies, top categories, and categories by year. The top ten data competency areas and the affiliated categories respond to RQ1. In response to RQ2, the results revealed a stable list of competencies over the ten-year analysis period.

Top data competencies

Our review sought to identify which exact skills and competencies librarians need to acquire to work with researchers seeking help with data-related questions. Figure 2 shows the top ten data competencies.
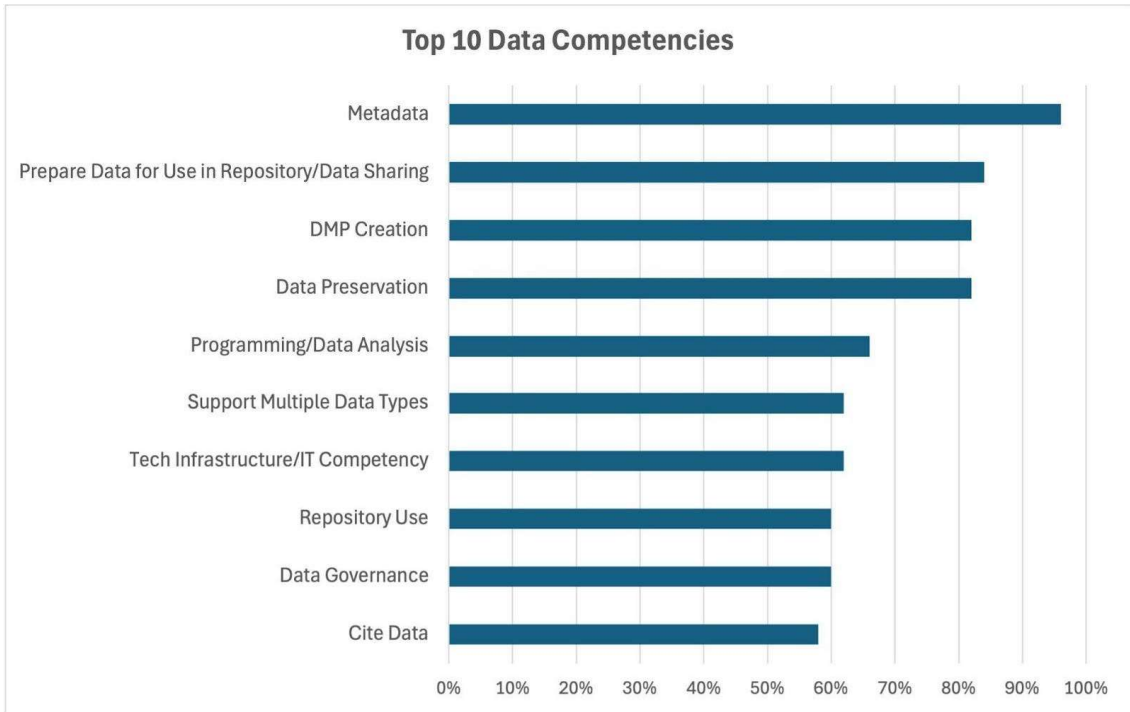

Figure 2. Top Ten Data Competencies

The top skill or competency that librarians need to master is *Metadata* or being able to help researchers understand what metadata is and how to create findable (useful metadata) that is discipline- or repository-appropriate. *Teaching researchers how to prepare data for use in a repository or for sharing* is the second most cited competency. This is defined as organizing data for reuse, utilizing the FAIR principles, creating Readme files, and ensuring files are in a software-agnostic file

format. *Data Management Plan (DMP) Creation* is next. In this competency, librarians must understand the parts of a data management plan and what information goes in each section. In addition, understanding the discipline-specific directorate-level requirements, can help with DMP creation. We also included the use of DMP generation tools, such as DMPTool. *Data Preservation* is defined as selecting data for preservation and considering the ongoing roles and responsibilities for the data, including long-term storage. *Programming/Data Analysis* was the fifth most cited competency. This includes purchasing and licensing tools for qualitative and quantitative analysis. It also encompasses understanding text mining, web APIs, data modeling, and data science. Teaching R and Python via the Software Carpentries in the library is an example (Pugachev, 2019).

Top competency categories

While our focus was on skills and competencies, we also considered the categories of competencies. Many of the articles focused on a specific category for training purposes. For instance, Data Curation was the focus of seven out of our 50 selected studies. Table 5 shows the top data competencies with their categories.

Competency	Category
Metadata	Data Curation
Prepare Data for Use in Repository/Data Sharing	Data Curation
Data Preservation	Data Curation
DMP Creation	Data Management
Programming/Data Analysis	Tools/Tech/Software
Tech Infrastructure/IT Competency	Tools/Tech/Software
Support Multiple Data Types	Data Curation
Data Governance	Data Curation
Repository Use	Data Curation
Data Publication	Data Literacy
Cite Data	Data Literacy

Table 5. Top Competency Categories

Data competency categories by year

We looked for trends in the competencies, but because there was so much variability in a competency from one year to the next, we couldn't draw any conclusions. Instead, we looked at categories to detect trends. First, we collected how many competencies/skills were noted in each year. Most articles discussed more than just one category; hence the counts add up to more than 100%. We then normalized the impact of the number of studies per year by dividing the counts within each category by the number of studies in the year. What we show in Figure 3 are the percent of skills addressed in each category. The lines show the trend over time. In the articles published in 2012, 63% of the categories in the Data Curation competency were discussed, 44% of the categories in the Data

Management competency were studied, 36% of the categories in the Data Literacy competency were mentioned, and 18% of the categories in the Tools and Technology competency were documented.
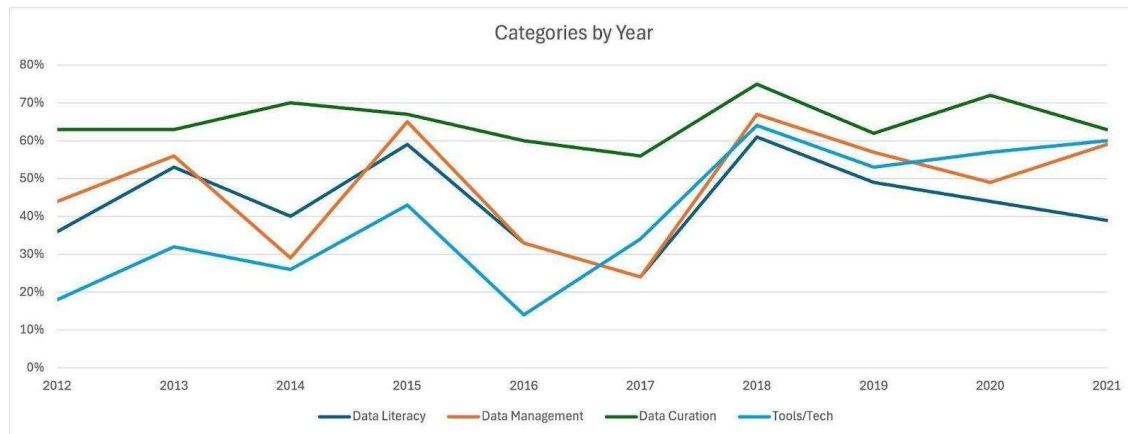

Figure 3. Data Competency Categories by Year

The Tools/Tech/Software category grew from 18% to over 60% in 2021, an overall growth rate of roughly 4% a year. Data Curation was relatively stable, in the 60-70% range. Data Management showed moderate growth, going from 44% in 2012 to 59% in 2021, growing about 3% per year. Data Literacy also remained relatively stable, rising from 36% in 2012 to 39% in 2021.

Discussion

When we began the process of searching and collecting articles from the library literature related to data competencies, most of the articles had to do with *researcher* needs. The literature was filled with surveys of what researchers felt they needed to learn to competently work with data. Some of the articles discussed how librarians addressed these needs. Fewer articles focused on librarian needs. While the researcher perspective and the librarian perspective are sometimes linked, it was only in a handful of articles that authors suggested that librarians who taught researchers could or should also learn these skills.

We started with the Tenopir article and used other studies that mentioned data competencies to develop our competency list. After reviewing the literature, we created the following competency categories: Data Literacy, Data Management, Data Curation and Tools/Tech/Software section. The skills in each category are unique and are often taught as separate units.

The studies we identified are largely surveys of academic libraries or librarians. The volume of research in this area has been relatively consistent over time and includes articles from institutions across the globe. Based on the literature, librarians all over the world do not feel confident in their ability to handle data-related queries.

We were surprised to find how little these skills had changed over the ten-year period. There was a consensus in the top ten skills that librarians need to know for working with data. While the need for tools/tech/software category of competencies grew over time, more basic data handling skills are still required.

The articles described research conducted on data competencies in 45 different countries. Data is an issue of concern for librarians across the globe. The top six countries represented in our collection are the United States, Canada, the UK, Australia, Germany, and South Africa. Research published from the

global south, such as India and South Africa, has been published in more recent years. This suggests that data-rich research and thus data competencies for librarians are a growing need internationally.

Since most of the studies we found are surveys, this data comes right from the librarians themselves. The strength of this type of research is that we heard directly from the librarians about the specific data skills they are concerned about. A weakness of this type of study is that it is typically administered via online form and can "lead" or bias participants to respond based on the specific questions asked. For example, librarians might be apt to select skills they'd like training on simply because it's on the survey.

A weakness, and a gap in the literature, is that we don't know why liaison librarians don't have or feel confident about working with data. Many information schools offer data-related courses. There are many online learning opportunities via self-paced modules from data-related organizations. Professional conferences regularly offer workshops for librarians at all levels of data expertise. Perhaps it has to do with the lack of time available for training, or the broad range or technical nature of data-related queries? Or it may have to do with the hiring of data specialists? If this is the case, research which examines how data specialists work with librarians and their division of responsibilities could prove illuminating.

One of the things that has shifted over time is federal funding requirements. Though not evident in our review (due to the time period we examined), the National Institutes of Health (NIH) has implemented stricter requirements for data management and sharing. In 2023, the NIH instituted a new Data Management and Sharing (DMS) Policy (National Institutes of Health, 2023). The policy emphasizes the completion of a data management plan that outlines how data and metadata will be managed and shared. It also encourages researchers to release the data as soon as an associated publication is ready, or at the completion of the grant, whichever comes first, without an embargo period. This indicates that managing and sharing data is becoming more important.

Another change the NIH is encouraging is sharing software and code as it relates to funded research. As part of supporting the dissemination of 'research products,' this initiative is intended to allow for reproducibility, and contribute to the advancement of science (National Institutes of Health, 2023). Thus, it's likely that librarians will also need to develop software curation skills.

Limitations

A scoping review presents some inherent limitations as a methodology. Among them, are the sources used to search, and the algorithms/terms lists may not be entirely comprehensive despite the best efforts of the authors. The review type also does not prescribe an assessment of quality, so the included studies may range in their own methodological rigor (Grant & Booth, 2009).

Other limitations include the inability to translate studies into English. Reviewing only studies published in English language journals limits the ability to have a global view of the competency landscape, which initially was one of our objectives. While we regret the inability to translate articles, we didn't want our results to be limited to North America. Here, we recognize the Western bias in the publishing landscape and acknowledge that this bias is carried through to this study.

Another limitation was that our coding method generated a sheet of yes/no responses. Using this method defined whether or not a competency was present in a research study. It did not drill down to the individual responses in a survey or quantify responses beyond the presence or absence of a competency. Thus, this work does not measure changing data needs but tracks changes in the presence or absence of these competency areas in the literature.

Initially, we planned to include liaison/subject librarians instead of all librarians and data-specific roles. However, this proved difficult as many of the surveys were not specifically sorted by the type of library role held by the respondent. Thus, we jettisoned this exclusion criterion. Though we speak broadly about developing data competencies, one of our objectives is to track what subject librarians/liaisons may need to support data. Thus, we have listed this as a limitation of the study.

Many articles discussed the category level (i.e., data literacy) of need, whereas other articles spelled out the skills (i.e., data citation). We were most interested in research that captured the skills librarians need to know. One of the more significant contributions of this review may be the enumeration of each skill/competency. Spelling out these skills and defining them makes them more transparent and can help librarians understand what type of training to take or offer.

Future directions

Research discovering how ingrained liaisons librarians are, specifically in data-rich research projects with departments, would benefit the broader data landscape. This work could help to better define a suspected liaison librarian task and potentially drive future hiring, particularly as data-rich research becomes the norm and open science practices are more fully embraced by researchers across higher education. Additionally, an examination of the types of positions that currently list data-related tasks would help to identify who is being asked to work on data-related needs and address the question of how siloed or cohesive the library services and data-related areas are becoming. More research is needed to identify what kind of data learning is offered in the information school curricula as we continue to see non-MLIS holders hired as data specialists. For librarians seeking to gain training, learning opportunities might be more useful if they specify what competencies will be gained or bolstered through the completion of the training and what prerequisites are recommended to grasp concepts.

Call to action: Data literacy courses should be required in information schools, especially for academic librarian tracks. Academic librarians need not be experts, but they should be familiar with data-rich research methods.

Conclusion

Many of the competencies identified in this retrospective scoping review are skills that liaison librarians are already well-versed in, such as finding data, metadata, and copyright. Other competencies might require structured or self-paced learning such as data management plan specifics, repository selection, and some of the more technically focused competencies, such as programming and data visualization. We suggest that librarians start by learning the skills near the top of the list to master skills in frequently identified competency areas. For example, a librarian could focus on training in the areas of Metadata, Prepare Data for Use in Repository/Data Sharing, Data Preservation, DMP Creation, and Programming/Data Analysis. Alternatively, they may wish to fully invest in learning a category of competencies, and start with Data Curation, so they'll be able to help researchers save their data which would enable reusability, potentially increasing researcher citation, and fulfill funder mandates. This category method of learning could prove particularly useful to libraries seeking to establish or broaden their data skills across multiple staff members. For example, two staff members could seek training in data curation, while others may seek training in data literacy.

It's clear upon completing this review that no one librarian is likely to be the expert in every competency. Rather, a library could benefit from a staffing model in which librarians choose to upskill in specific competencies or categories, and other librarians or library staff take on other competencies. This shared expertise model could enhance the research support ecosystem by strengthening relationships among librarians and library staff in different units, particularly at larger institutions.

When institutions hire data librarians, they should be integrated into the collaborative ecosystem of research support that includes liaisons, public services experts, and technical services. This ecosystem would ideally operate seamlessly in sharing information and knowledge of each area of expertise. Liaisons and other librarians have cultivated relationships with faculty and research groups on campus. Building trust and a support structure between librarians and data librarian/specialist roles is essential to creating an ecosystem where data-specific roles are relied upon for their expertise. Likewise, librarians who have a deep subject knowledge may be better equipped to work with a researcher on a project (Federer, 2018) and may themselves be eager to develop data-related skills. As data-rich research continues to gain traction and be supported by libraries, the research support ecosystem is becoming more complex. As research services continue to develop, researchers and libraries alike will be better served by an integrated service model that allows librarians to explore and develop new competencies such as those described in this review.

In conclusion, data is but another form of information. Librarianship is the profession that helps users to find, evaluate and ethically use information. Yet, we are grappling with adding new tasks to overfilled plates and trying to determine where data-intensive skills fit in our institutions. How these data-related demands will be met in the future may swing back toward requiring a credentialed librarian as more librarians seek to self-train and the credentialing process for academic librarians moves toward data competencies.

Funding

Associated documents

Associated documents including protocol planning, definitions, and data charting can be consulted at the Open Science Framework: https://osf.io/qa5vr/

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