



CHAPTER 6*

Research Data Services Maturity in Academic Libraries

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Introduction

In 2012 only a small number of academic libraries offered research data services (RDS), but many were planning to do so within the next two years.¹ By 2013, 74 percent of respondents to an Association of Research Libraries (ARL) survey offered RDS, and an additional 23 percent were planning to do so.² Stimulated by shifts toward computational paradigms and the issuance of federal mandates to increase access to products of federally funded research, academic libraries recognize that the landscape of services changes quickly and that they need to support the changing needs of research and instruction.

To provide effective support for their constituencies, libraries must be proactive and develop services that look forward and yet accommodate the existing human, technological, and intellectual resources accumulated over the decades. Setting the stage for data curation in libraries means creating visionary approaches that supersede institutional differences while still enabling diversity in implementation. How do academic libraries approach data curation? What constitutes

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an established RDS suite in an academic library? What can help in RDS evaluation, comparison, and improvement?

This chapter sets data curation in academic libraries within the broader context of RDS development and combines a historical overview of RDS thinking and implementations with an empirical analysis of libraries' RDS goals and activities. Using historical and current empirical data, the chapter synthesizes the state of RDS across academic libraries and argues that curation needs to be seen as part of a larger suite of services offered by libraries in support of the research life cycle and that the services evolve over time. To better understand this evolution and compare RDS across institutions, the chapter offers an empirically based framework of RDS maturity. A set of recommendations that libraries might consider to advance their RDS to the next maturity level is provided at the end.

Research Data and Libraries

Since the 1950s, if not earlier, much of the work around data has been done by research communities as they grappled with global, inter-institutional data management and archiving.³ North American academic libraries have also worked toward establishing research data services, though their services have often been anchored within their institutions. These early library data services were prominent in the areas of social science and GIS data reference and acquisition, but also in stewardship and sharing of data.⁴ Conversations about data stewardship and the library's role in it tended to focus on needs within the university community. Thus, in 1965 I. de Sola Pool argued that

The storing of basic data in retrievable and manipulable form is, indeed, a library function. The library is an archive of that type of information that is of interest to many members of the university community and that is too bulky or expensive for each to retain or own. Each member of the faculty owns some books, but no member of the faculty can afford all the books he needs. The library provides the economy of shared-book usage. If this is a function of the library in the university, then clearly data archives also belong in the library....

Obviously, many data collections are so bulky or so expensive or so private that not even a university library can hope to own them. That, however, only suggests that specialization, division of labor, and linkage among libraries in a total library system are necessary in this field, as in other fields.⁵

The discussions of the 1970s and 1980s focused on staffing, institutional support, and computerized services to digitize and assist with machine-readable data.⁶ The services of early data facilities already included acquisition, preservation, data cleaning, metadata, access and retrieval, reference, and data citation.⁷ At the same time, libraries played a smaller role; among the forty-eight data-sharing facilities in the North America listed by Clubb et al. in 1985, thirty-one were associated with universities, with most of those facilities operating as collaborations between research and computing centers and sometimes libraries.⁸ The Social Science Data and Program Library Service (DPLS) at the University of Wisconsin-Madison, for example, was established primarily by the faculty and could not be absorbed by the library because library staff at the time were not skilled in computers and data.⁹

In the late 1990s–2000s, with digital data and new forms of research on the rise, discussions shifted towards e-science, cyberinfrastructure, and digital curation, stimulated particularly by several seminal reports from the United States and the United Kingdom.¹⁰ ARL recognized the importance of building members' awareness of the changes coming with the emergence of e-science and identified policies, skillful workforce, and research infrastructure as the primary areas of library engagement.¹¹ Data services have also been organized into tiers or areas that libraries could use to determine their current state, identify service gaps, and set goals and priorities.¹² Guidance on the development of data curation services “downstream” and “upstream” in the research life cycle was another way to define libraries' roles with RDS.¹³

A number of studies that examined the state and development of RDS in academic libraries show a clear trend of more academic libraries providing a broader range of e-science support and data-related services. In 2010, among 57 ARL libraries surveyed, 21 (37%) reported providing infrastructure or support services for e-science, with the rest being in the planning or no support stages.¹⁴ Many libraries offered such services as information dissemination, consultations, and reference, as well as technology support (e.g., storage or software). A few libraries mentioned providing curation, stewardship, and preservation services. The common pressure points among the libraries included staffing and lack of infrastructure to handle, preserve, and provide access to data.

In 2012, about 44 percent of academic libraries surveyed provided reference support for finding data, and 20 percent or less provided other types of data-related services.¹⁵ The services offered were predominantly in the informational or consultative category, such services as outreach and collaboration, training, and consultations. Creating web guides to help users find data and relevant information was one of the most common types of RDS among academic libraries. A rather rare category of technical or hands-on RDS included creating metadata and preparing, identifying, and deaccessioning data. The report also found that institutions with external funding were more likely to be involved in RDS de-

velopment, suggesting that funding agency requirements were driving the need for RDS.

By 2013, 74 percent or 54 of the ARL respondents offered RDS,¹⁶ with many of them providing guidance and assistance with data management plans (DMPs). Three challenges identified in the ARL survey were (1) hiring and retraining staff, (2) building technical infrastructure, and (3) reaching out and collaborating with other stakeholders on campus. Research data management has been argued to be a major change in most librarians' responsibilities, as "data require different structural metadata, schemas, and vocabularies. Librarians who have adapted their skills are difficult to find."¹⁷ ARL institutions approached RDS issues in diverse ways, and it was predicted that RDS would evolve over the next several years,¹⁸ depending on institutional and funder policies as well as on financial and human resources available.

The Current Landscape

To map the current landscape of RDS in academic libraries, we conducted a study of the 124 ARL libraries (as of September 2015) as those most likely to have started providing or planning for RDS. The study included content analysis of library webpages and a series of interviews with library administrators and program leads that examined their views of RDS goals, activities, and evolution. For content analysis we identified data-related webpages on library websites and coded their content for (1) the presence or absence of references to local repositories and to librarians dedicated to RDS, and (2) the presence or absence of references to particular types of services. The interviews were recorded and examined for common themes and specifics of RDS implementations. The results from both content analysis and interviews were used in a synthesizing depiction of the current landscape.

About half of the libraries (52%) indicated that they have a dedicated RDS position or librarian role on staff. The nature of dedicated positions varied from single librarians leading data services, to liaison librarians taking on research data management consultations, to full units or departments with multiple data consultants or specialists. This variety is consistent with earlier studies that found a range of staffing models and diverse position titles.¹⁹

The typology of services was developed using categories from the literature as well as from our own study.²⁰ The typology distills the surveyed libraries' service offerings into their core functional areas, such as "consultation and instruction," "collaboration and engagement," or "archiving and preservation" (see also appendix 6A for details on typology). Identifying core functional areas among varying implementations enabled us to consistently compare services across institutions and count their frequencies (see table 6.1).

TABLE 6.1
Research Data Services in the ARL Libraries

Group^a	Type of Service	% Libraries Mentioning Service on Website (N = 124)
<i>Basic</i>	DMP assistance and mandate support	74%
	Consultations and instruction	73%
	Best practices and information dissemination	72%
<i>Intermediate</i>	Data deposit and repositories	49%
	Archiving and preservation	42%
	Collaboration and engagement	31%
	Metadata	30%
	Storage	27%
	Sharing and reuse	27%
<i>Advanced</i>	Data and researcher IDs	14%
	Data processing and analysis	13%
	Data curation	12%
	Acquisition	11%
	Copyright and ethics	10%
	Software and hardware	10%
	Data citation	10%
	Policies	7%
	Data reference	6%

a. Grouping is based on the frequency of service occurrence in the libraries, see more at the end of this section.

According to the webpages, most libraries (74%) provide DMP assistance and mandate support, including links to the DMPTool, an online service that contains DMP templates and allows researchers to create DMPs according to the funding agency requirements. Consultation and instruction as well as best practices and information dissemination are two other most frequent types of services (73% and 72%). Such capacity and partnership building is often mediated by subject librarians who are learning data management issues relevant to their disciplines and are ready to offer guidance on data management requirements for particular funding agencies.

The services of data deposit, archiving and preservation, collaboration and engagement, metadata, storage, and sharing and reuse were mentioned on fewer

webpages, ranging from 49 percent to 27 percent. These services require a higher level of institutional engagement and more financial, technological, and human resources. At the same time, developing a repository for data, or, more frequently, adapting an existing institutional repository to accept data, is a common second step for libraries offering data services. Thus, several of our respondents noted that they plan to pilot repository software and explore consortial options for data archiving. Despite only 49 percent of the libraries referring to data deposit as a service, many more (70%) had a repository that enabled data deposits. As data deposit requires efforts that are related to archiving and preservation, data and researcher IDs, and data curation, the beginnings of such services could have been considered part of many RDS efforts. Nevertheless, oftentimes such services were not specified as areas of concerted effort, and activities of deposit and preservation were used interchangeably.

A number of services were offered in less than 15 percent of the libraries, including permanent IDs for data and researchers, data curation, data processing and analysis, software and hardware support, data reference, and data citation. These kinds of services often depend on the specific user needs; additionally, they require a higher level of skill and expertise on the part of the library staff who offer them. A data reference librarian, for example, can be expected to be familiar with statistical software such as SPSS and understand how to manipulate numerical data in such software.*

A striking difference in preservation efforts (42%) and curation efforts (12%) can probably be attributed to the differences in terminologies that various libraries employ to describe their efforts as well as to the awareness of the fuller spectrum of data services. At earlier stages of RDS, the terms “*preservation*” and “*curation*”, for example, can be used interchangeably. At more advanced stages of RDS, terminology becomes more specific because it refers to specific goals, tasks and responsibilities within a library. While the services of storage, archiving and preservation, and curation are connected and dependent on each other,²⁰ they become differentiated and sometimes specialized due to unique partnerships with IT units and commercial services.

Services that were the least common across libraries included support for copyright and ethics, software and hardware, data citation, and policy development. These areas are among the most challenging to implement in the libraries, as stakeholders in data exchanges—including producers, providers, publishers, and consumers—are trying to understand the best ways to ensure open sharing while protecting ownership and to create tools for storing, analyzing, and sharing data at scale. Many respondents in our study confirmed that some work on devel-

* See, for example, a data reference librarian job description: “Data Reference Librarian,” job opening at Harvard College Library, posted to IASSIST August 20, 2008, <http://www.iassistdata.org/resources/jobs/1612>.

oping data policies was being done, but it involved university-wide consultations and collaborations with institutional review boards, research administration, and information technology units. Some libraries, while acknowledging the need for data policies to guide their service provisioning and to enable data sharing, postpone such work as it needs to be consistent with the funding mandates, publishing policies, and other areas that involve data. The early work on data policies includes efforts to incorporate data management into institutional research policies and to increase awareness of the existing policies with regard to sensitive data and data ownership within universities.

To provide an additional way of comparing RDS across academic libraries and to build the foundation for the discussion about RDS maturity below, the typology of services is further grouped into three categories based on the *frequency of service occurrence* in the libraries: the **basic** services group includes services that exist in more than 50 percent of the libraries, the **intermediate** services group includes services that exist in less than 50 percent but more than 15 percent of the libraries, and the **advanced** services group includes services that exist in less than 15 percent of the libraries. While frequency alone cannot be an indicator of RDS maturity, such an approach has found support in our interviews and in the literature. Respondents in our interviews reflected that DMP services were typically the first type of services they offered when starting RDS at their institutions, while also noting that they needed to move beyond that and basic policy compliance and informational services. Similarly, Fearon noted that many libraries started their RDS with support for DMPs, with almost 90 percent of the libraries providing DMP support and consultation services.²² The basic group of services naturally lends itself to the beginning stages of RDS development as it is a straightforward outgrowth of the work librarians do in advisory and reference services and is relatively easy to implement; the intermediate and advanced groups require more skills, better stakeholder engagement and institutional support, and more resources.

RDS Maturity

In the previous section, we introduced a typology of data services and, based on our content analysis and interviews, posited that the most frequently offered services are those that represent a straightforward entry point into RDS, while those that are more challenging—more resource-intensive, more specialized, and more reliant on institutional support—are both rarer and more advanced. In the following section, we develop this initial statement into a maturity model for RDS.

Maturity evaluation is a common approach to determining the level of sophistication of services or products. One of the earlier, better known examples of such models, the Capability Maturity Model for Software (CMM-SW), was

developed in the 1990s to aid the US Department of Defense in software acquisition.²³ The model's goals were to appraise software processes and help organizations to move from chaotic ad hoc processes of development to disciplined and optimal ones.²⁴ The model developers distinguished between immature and mature software organizations and argued that the former are primarily reactionary and focus on solving immediate problems, while the latter are based on solid management techniques, such as consistent planning, communication, pilot testing, cost-benefit analysis, and defined roles and responsibilities.

Recently, Qin, Crowston, Flynn, and Kirkland proposed using maturity levels similar to the CMM-SW to assess and improve research data management (RDM) practices in research projects.²⁵ They described the five levels in application to RDM as follows. The first, *initial* level of RDM relies on competent individuals and heroic efforts, making the data management efforts unreliable. The second, *managed* level of RDM is based on the procedures and policies established in advance for each project, which makes it difficult to apply RDM across projects. The third, *defined* level is characterized by established and repeatable procedures that can be used across projects. The fourth, *quantitatively managed* level adds metrics that help to evaluate processes and progress. The final, *optimizing* level focuses on improvement and identification of weaknesses and inefficiencies that can be addressed proactively. The maturity levels are suggested to be applied to the following key process and practice areas: (1) data management in general; (2) data acquisition, processing, and quality assurance; (3) data description and representation; (4) data dissemination; and (5) repository services and preservation.

The capability maturity framework guide for data management proposed by the Australian National Data Service (ANDS) uses the same maturity levels as CMM-SW and CMM RDM, but it identifies different process areas: (1) institutional policies and procedures; (2) IT infrastructure; (3) support services; and (4) managing metadata.²⁶ For each of the areas, the processes move from being ad hoc and disorganized to being defined, standardized, managed, and optimized. Yet, there is one major difference. The CMM-RDM framework fits with the research life cycle approach and, with data management, can be applied to the stages of data collection, processing, dissemination, and preservation and, therefore, can be applied at the project level. On the other hand, the process areas of the ANDS model identify larger areas within the institutional context (e.g., policies, infrastructure, education, and metadata) that need to be in place before data management within the life cycle can take place.

These models, and many other capability models that have been developed over the last few decades,²⁷ provide guidance in terms of the trajectory that a team, a project, a service, or an organization can go through to become a well-managed unit with clear goals and path toward deliverable results. At the same time, the models offer rather loose definitions of each level and leave it up to the user of the model to determine whether the processes within an organization are sufficient-

ly organized, documented, managed, or optimized. CMM-RDM provides more guidance, but it is an outward looking model; that is, it guides the development of data management for data management “consumers,” such as researchers or data managers, rather than librarians. It is also not clear how much empirical ground-work went into the process areas development and maturity levels. An “inward” approach to maturity modeling that looks at data management “providers,” or organizations supporting research in academic institutions, will better suit the needs of research data services being developed and evaluated in academic libraries.

Similar to the maturity of software development or data management, RDS maturity can be defined as the extent to which specific services are defined, managed, and evaluated in their impact and effectiveness. Each service and the system of services as a whole can be evaluated in its richness and consistency with the overall organizational goals. To be well-developed and well-understood throughout an organization, RDS need to rely on dissemination and training, and constant user feedback. Maturity also implies consistent growth and improvement via a disciplined and optimized approach.

The difference between software development and RDS is in how growth over time and improvements are conceptualized. In the context of software development, the goal is to improve processes in order to more quickly, reliably, and effectively turn out new products, often in a competitive market environment. For academic libraries, however, there is a complex interaction between the goals of RDS and the bigger strategic goals of the library and the institution; further, individual institutions’ RDS efforts are just one part of a complex and largely cooperative network of data support, which includes external entities such as disciplinary and other repositories, funders and their initiatives, commercial services, and so on. As a result, the highest, optimized level of maturity may have a different meaning for various institutions depending on their missions and goals. Knowing where the “finish line” is in terms of the nature of services provided in a particular institutional context is as important as knowing what services to implement.

The key areas and levels proposed in the maturity model in table 6.2 are based on our empirical analysis of the ARL libraries, particularly on the analysis of interviews with library administrators and program leads regarding their views on immediate RDS implementation directions, short-term goals, and future plans. While analyzing the interviews and extracting common themes and approaches, we found that many interviewees agreed that in order to develop strong and mature RDS, a library needs to have the following: a mission that is consistent with the institutional mission, services that match user needs, qualified and dedicated staff, strong relationships with other units on campus and with other institutions, and established policies that guide data collection, sharing, and use. The synthesis of these themes along with many other discussions mentioned above formed the basis of eight key areas of maturity: leadership, services, users and stakeholders, research life cycle support, governance, cost and budgeting, cross-unit collaboration, and human capital.

TABLE 6.2
Research Data Services Maturity Model

Maturity Levels Key Areas	Basic :: Foundation Building	Intermediate :: Organization and Standardization	Advanced :: Monitoring and Optimization
<i>Leadership (vision, strategy, culture)</i>	Response to mandates and external activities	Data strategies are coordinated with institutional strategic documents.	Data strategies guide service development and assessment.
<i>Services</i>	DMP assistance, consultations and instruction, best practices and information dissemination	Data deposit and repositories, archiving and preservation, collaboration and engagement, metadata, storage, data sharing and reuse	Permanent IDs for data and researchers, data curation, data processing and analysis, software and hardware, data citation
<i>Users and stakeholders</i>	Addressing individual requests	User strategy is based on needs assessment.	User needs are regularly evaluated, and services and needs shape each other.
<i>Research life cycle support</i>	Support on one end (upstream with DMP or downstream with data deposit)	Support broadens and formalizes for both upstream and downstream.	Support is embedded in the life cycle.
<i>Governance</i>	No policies, or reliance on institutional policies	Data mentioned in other policies or one general data policy	Set of policies from acquisition to storage to curation and dissemination
<i>Cost and budgeting</i>	Spending is a burden; each data-related expense needs to be requested and justified.	Spending brings benefits and creates opportunities.	Budgeting for growth and sustainability
<i>Cross-unit collaboration</i>	None, or ad hoc meetings and committees within institution	Joint initiatives with other units	Formal partnerships within and outside, support from university administration
<i>Human capital</i>	Other staff, such as subject librarians, assume data responsibilities, ad hoc training	Solo librarian or a working group, consistent professional training	Dedicated team with shared or specialized responsibilities, strong skills, continuous learning

The RDS maturity levels are simplified from five to three as compared to other CMMs to aid in clearer definitions and subsequent validation effort. The three levels also effectively represent the diversity of RDS approaches among the academic libraries in our study, which corresponded to the basic, intermediate, and advanced categorization and converged on the following three stages: (1) foundation building, (2) organization and standardization, and (3) monitoring and optimization.

During foundation building, the library focuses on implementing services that do not require significant resources and expertise, and it is done with limited staff support. The implementation efforts are mostly driven by mandates and individual user requests, and no significant cross-unit collaboration and user assessment exists. Each data-related expense needs to be justified because it potentially takes away from other library activities.

At the level of organization and standardization, the library gets involved in strategic efforts to coordinate its activities with the institutional goals and mission. The leadership becomes less reactive and more focused on a stronger view of the future and the role the services will play in shaping it. The services are customized to meet institution-specific requirements; they are based on user needs assessment and cross-unit collaboration. Professional development becomes part of the library activities, and spending becomes more organized to spur further development.

At the monitoring and optimization level, services become more diverse and become embedded in the research life cycle. The library not only engages users and stakeholders and understands their needs, but also develops an effective feedback system. The library also develops a comprehensive set of policies and strategic documents and builds formal external and internal cross-unit partnerships. The data services team structure and organization moves from solo librarians to dedicated, multifunctional, or specialized teams.²⁸

Looking into the Future

As academic libraries continue to grow their RDS programs, there are two areas of strategic activities that are of primary importance in developing appropriately targeted, effective services. First, libraries need to continue to assess what their peer institutions currently offer and ask: How similar and different they are? What they are trying to achieve? What they have learned and would do differently? and, more importantly, Why they are offering those particular services? Second, libraries should also aim for service development that is not simply reactive; developing a vision for RDS is a critical precursor to selecting impactful services to implement. This study provides a baseline that can be used to trace RDS development and improvements across institutions as well as a model for evaluating and building RDS programs.

A key take-away from this study is that more advanced services are probably those that are most closely targeted to the needs of individual institutions' communities but are also cognizant of the broader research communities to which individuals belong. The institutional approach is one way to address RDS needs, and academic libraries are playing an important role in the national and global data ecosystem.²⁹ More mature RDS programs are not necessarily those that offer the longest menu of services or employ the largest number of staff, but rather those whose activities are more deeply embedded in the mission and activities of the library and the broader institution. Mature RDS services have strong connections within and outside the library, a plan for sustainability in place, well-developed policies, and so on. In other words, a mature RDS program is one where services are chosen carefully, and then carefully organized, monitored, and optimized.

To some extent, high levels of maturity reflect a high level of organizational buy-in: a sustainable budget for RDS, for example, is not something that can be accomplished in isolation. Our maturity model for RDS serves a dual purpose; it is a useful tool for identifying gaps and setting priorities, but it can also be a valuable tool for communicating with library administration. Part of developing RDS is asking for resources and support from the library, which means it is important not only to express the goals and vision for RDS specifically, but also to align them with the broader strategic goals and vision of the library and the institution. Many respondents in our interviews acknowledged resource limitations and recognized the importance of such an alignment.

Opportunities abound in building RDS. For libraries looking to take the next step with their services, it is critical to determine which opportunities are aligned with their priorities, whether it is developing a new service, building partnerships, or planning for assessment of existing services. Looking at what services peers offer as well as self-assessing a library's current RDS maturity level helps to sort out which opportunities will provide the most value in the long run.

Appendix 6A: Typology of Services and Their Descriptions on Websites

Type of Service	Explanation
<i>Acquisition</i>	Statements that describe acquisition and collection management with regard to data
<i>Archiving and preservation</i>	Statements that describe long-term archiving and preservation of data
<i>Best practices and information dissemination</i>	Statements that describe efforts to collect and disseminate information about (best) practices in data management and sharing, mostly via websites and other similar types of materials
<i>Collaboration and engagement</i>	Statements that describe efforts to engage with faculty, other units on campus, or other organizations
<i>Consultations and instruction</i>	Statements that describe consultation and instruction initiatives, including workshops, seminars, and so on (more active orientation than dissemination)
<i>Copyright and ethics</i>	Statements that describe efforts to providing information about intellectual property and ethical uses of data
<i>Data processing and analysis</i>	Statements that describe assistance and guidance on data processing and analysis resources and issues
<i>Data and researcher IDs</i>	Statements about services that help to create and maintain permanent identification for people and documents
<i>Data citation</i>	Statements about guidance on how and why to cite data
<i>Data curation</i>	Statements that describe activities of curation with regard to data
<i>Data deposit and repositories</i>	Statements that describe assistance in finding and using appropriate repositories (disciplinary or institutional)
<i>Data reference</i>	Statements about reference-type services, including search, sources, and use of tools
<i>DMP assistance and mandate support</i>	Statements about assistance with DMPs and compliance with funding agencies mandates
<i>Metadata</i>	Statements about assistance with generating or structuring metadata
<i>Policies</i>	Statements about creating, developing, or providing policies with regard to data
<i>Sharing and reuse</i>	Statements that describe support of sharing and reuse
<i>Software and hardware</i>	Statements that describe efforts to provide or inform about hardware and software resources to process and analyze data
<i>Storage</i>	Statements that describe efforts to provide short-term and long-term storage for data

Notes

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