

Research and Construction of a Research Data Management Service Framework: A Case Study of Peking University (Postprint)

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Abstract

[Purpose/Significance] Through an environmental scan of domestic and international data-driven research, this study examines the progress of research data management services at home and abroad, proposes recommendations for a research data management service framework and for serving the research life-cycle, and uses the practice of Peking University Library as an example to provide research and practical reference experience for universities and research institutions in offering research data management services and promoting data-driven research. [Method/Process] This study investigates the current status and trends of data-driven research domestically and internationally, analyzes the development of research data management services worldwide, and highlights the importance of such services. Service requirements are summarized through user surveys and investigations of services at QS top 50 universities. Based on the characteristics of the data-driven research paradigm and researcher needs, in accordance with data policy requirements from national governments, international organizations, funding agencies, and research institutions, and grounded in the principle that the research data lifecycle must serve the research lifecycle, a research data management service framework is proposed. The experience of Peking University in building its research data management service framework is introduced to provide recommendations for the construction of such frameworks. [Results/Conclusion] Based on the needs assessment, a research data management service framework supporting the entire academic communication process is designed. Research data management services should include: data management planning, data services, data management, data literacy, long-term preservation, and data policies. Under this framework, Peking University Library has implemented research data service practices from multiple dimensions, providing valuable reference experience for universities and research institutions in building research data management services.

Full Text

Preamble

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Abstract

[Purpose/Significance] Through a comprehensive environmental scan of data-driven research both domestically and internationally, this paper examines the progress of research data management services worldwide and proposes a framework for research data management services and the research lifecycle. Using the practice of Peking University Library as an example, it provides reference experience for universities and research institutions to develop research data management services and promote data-driven research. **[Method/Process]** The study investigates the current status and trends of data-driven research globally, analyzes the development of research data management services at home and abroad, and highlights the importance of such services. Through user surveys and investigation of services at QS top 50 universities, service demands are summarized. Based on the characteristics of data-driven research paradigms and researcher needs, and in accordance with data policies from national governments, international organizations, funding agencies, and research institutions, a research data management service framework is proposed that serves the research lifecycle based on the data lifecycle. The paper introduces Peking University's experience in building its research data management service framework to provide recommendations for framework construction. **[Result/Conclusion]** The framework designed to support the entire academic exchange process includes: data management planning, data services, data management, data literacy, long-term preservation, and data policy. Under this framework, Peking University Library has implemented research data services across multiple dimensions, offering valuable reference experience for universities and research institutions building research data management services.

Classification Number: G251

Keywords: data-driven research, research data management, data service framework, data service, data policy

2. Research Progress and Trends in Research Data Management Services

2.1 Demand for Data-Driven Research Services

Higher education is undergoing transformation, with data science and data-driven research becoming global priorities that require data management service support. According to StudyPortals, 104 U.S. universities currently offer undergraduate programs in “Data Science & Big Data.” In China, Peking University, University of International Business and Economics, and Central South University were the first to establish the “Data Science and Big Data Technology” undergraduate major in February 2016. The second batch in March 2017 approved 32 additional universities, and the third batch in March 2018 approved 248 institutions—nearly eight times the total of the previous two rounds combined [7]. This rapid expansion demonstrates that data science has become a popular field requiring robust teaching and research support services.

Data-driven research has become a cross-disciplinary trend, creating urgent demand for data services. From November 24, 2017 to April 3, 2018, Peking University Library, the Department of Information Management, and the South China Sea Big Data Application Research Institute of Hainan Province organized the “First National University Data-Driven Innovation Research Competition” (hereinafter “the Competition”). The event attracted 1,892 students from 169 universities (593 teams) across 56 first-level disciplines [8], indicating that data-driven research has become a universal academic trend. User needs for data resources are gradually surpassing those for literature, making data-based research the new norm.

2.2 Research Progress and Trends

2.2.1 Policy-Driven Service Development Internationally, successive data policy releases have propelled global research data management and open services forward. In 2011, the U.S. National Science Foundation began requiring data management plans in grant proposals, with multiple U.S. funding agencies following suit [10]. The UK’s Digital Curation Centre (DCC) published guidelines on developing data management and sharing plans in 2011 [11]. In July 2012, the Royal Society released the report *Science as an Open Enterprise*, establishing principles, opportunities, and challenges for open scientific data [12]. The G8 Summit in Northern Ireland signed the Open Data Charter in June 2013, proposing five requirements: (1) make open data the default, (2) focus on data quality and quantity, (3) ensure usability for all, (4) improve data release management processes, and (5) publish data to serve innovation [13]. Finland’s Academy of Finland advocated for open sharing of research results and data in 2014 [14]. The EU Horizon 2020 program mandated full implementation of research data openness from 2017 to promote its “Open Science” strategy [15].

On August 31, 2015, China’s State Council issued the *Outline for Promoting*

Big Data Development [16], promoting scientific big data development and encouraging gradual open sharing of scientific data from publicly funded research activities. The National Natural Science Foundation of China released open access policies and detailed rules in 2014-2015 [17] and launched a funded results repository [18], formally initiating China's open access movement, though open data policies and platforms are still pending.

The *Measures for Scientific Data Management* issued by China's State Council on April 2, 2018 [9] strengthened and standardized research data management throughout its lifecycle to promote open sharing. Under these circumstances, building a world-class research data management service framework for data aggregation, management, and services has become essential for leading universities.

2.2.2 Service Framework Research Review Demand drives service development, making research data management a critical service for research universities and libraries. Related research and practice are developing rapidly. Current research on research data management service frameworks focuses primarily on service surveys, service content frameworks, case studies, and data literacy education.

Service Surveys: In 2014, DCC surveyed 87 administrators from 67 UK research institutions, revealing uneven investment in RDM funding, personnel, and infrastructure [21]. Tenopir et al. surveyed 119 European university libraries in February 2016 [22], finding over 90% had implemented or planned data policy, data management planning, and literacy training services, but only 31.9% provided data services during research projects. Cox et al. surveyed 170 libraries across Australia, Canada, Germany, Ireland, Scotland, New Zealand, and the UK in 2017, showing that while institutions highly recognized data policies and service intentions, they lacked high-quality RDM services overall [23]. Yoon and Schultz analyzed 185 U.S. research university library websites in 2015, identifying main services as: consultation/help (79.5%), data deposit (60%), data management planning (41.1%), data consultation (38.4%), data publishing and sharing (27.6%), and data methodology (15.7%) [24].

Service Content Frameworks: In March 2017, OCLC published the "Research Data Management Realities" series, summarizing three RDM service domains: education (data awareness, preservation concepts, policies, methods, tools, resources), solutions (personalized services by data librarians for research processes), and long-term preservation (data management across the research lifecycle, identifiers, rights management, metadata, versioning, preservation) [25]. The Australian National Data Service (ANDS) proposed five elements of data management capability: policy and processes, information architecture, service capacity, metadata management, and research data management [26]. The UK's Digital Curation Centre recommended that research data management support frameworks cover policy and planning, sustainability, data management plans, metadata, storage, archiving strategies, data management, and

training guides based on the research lifecycle [27]. Cui Yuhong referenced the ICT4D model to develop an RDM4D model cube, clustering 21 key practices into four process areas across three research stages: creating data management plans before funding applications; organizing, describing, and storing data during projects; and preserving and accessing data after project completion [28].

Case Studies: Domestically, Fudan University, Peking University, and Wuhan University have pioneered RDM services without yet releasing data policies [29-31]. Internationally, services are widespread due to national and funder requirements, with numerous case studies focusing on institutional practices [32-34]. The University of Queensland, for instance, provides lifecycle-based services covering: (1) project planning (funding and ethics approval, IP and legal issues); (2) project implementation (data collection, processing, analysis); and (3) archiving, publication, and dissemination [35].

Data Literacy: Since 2014, Peking University Library's data librarians have conducted data literacy training through their "One-Hour Lecture" brand, covering data resources, software tools, analysis/mining tools, and academic standards. In 2018, they launched a data resource navigation, offering access to 422 data resources by October 2018 [39]. The OCLC report specifically noted that data consultation must be face-to-face services provided by librarians rather than email, phone, or online support.

Literature review reveals that domestic RDM service research and practice remain relatively underdeveloped, with limited research output focusing on international policies, services, and demand surveys, while platform construction and service implementation progress slowly. International research primarily covers surveys and case studies, lacking in-depth framework studies and specific construction recommendations.

3. Framework Design for Research Data Management Services Supporting the Entire Academic Exchange Process

3.1 Demand Survey

In 2014, our team conducted a questionnaire survey of faculty at Peking University, obtaining 50 responses, followed by one-on-one interviews with 26 faculty members closely involved with research data. The survey found that 87.5% of respondents were willing to share research data under certain conditions, primarily motivated by enhancing data value, increasing citation rates, and improving data visibility. Their greatest concern was others using their data to publish first. Among sharing conditions, "reviewing user identity and data usage purpose" was most needed.

In 2018, to identify core RDM tools and services, two librarians from the University of Toronto recruited 28 faculty members through focus groups, identifying four key RDM service concerns: (1) infrastructure supporting the research process, (2) data security, (3) data management skills, and (4) copyright protection

for published data [36].

3.2 RDM Service Survey

The author investigated RDM services at QS World University Rankings top 50 universities in 2018 (18 in the U.S., 2 in Canada, 9 in the UK, 5 in Australia, 2 in Switzerland, 7 in mainland China and Hong Kong, 1 in France, 2 in Singapore, 2 in Japan, and 2 in South Korea). The survey examined whether and what services were provided, revealing that services mainly included: data management planning, data services, data literacy, data management, long-term preservation, and data policy. The study found that with policy support, nearly all top 50 universities outside Asia provided RDM services, while Asian universities lagged behind. Among service components, data management planning and data services were well-developed, while data management and long-term preservation required strengthening.

Table 1 shows the RDM service content survey results for QS top 50 universities.

3.3 Framework Design

The survey identified that data-driven researchers need: (1) services meeting international funder requirements; (2) data services supporting teaching, research, and publication; (3) data management infrastructure and services for research processes; (4) data skills and knowledge for data-driven research; (5) long-term preservation services; and (6) data policy, literacy, and intellectual property services.

Based on data-driven research characteristics and researcher needs, and considering requirements from national and international policies, the framework recognizes the close relationship between the data lifecycle and research lifecycle (see Figure 2 [Figure 2: see original paper]). The proposed research data management service framework includes six components: data management planning, data services, data management, data literacy, long-term preservation, and data policy. Table 2 presents the framework design, while Table 3 details the service content for each component. Institutions can reference this framework and adapt it to their actual needs.

Under this framework, to support the new academic exchange ecosystem [37] and meet data service needs across research cycles (see Figure 3 [Figure 3: see original paper]), services should support complete data needs throughout the academic exchange process (see Figure 4 [Figure 4: see original paper]). During research preparation, researchers need to understand frontier directions and track hotspots for project proposals, supported by data management planning, data services, and literacy training. In the discovery phase, complete literature and data resources are needed, provided through digital resource navigation and open data platforms. During analysis, project management and

data services support research processes. In publication, IP policy consultation helps researchers disseminate results and enhance impact. In promotion, data platforms and preservation systems facilitate publication, archiving, and dissemination while supporting teaching. For research evaluation, data services and preservation support comprehensive assessment and new research initiation. The framework aims to fully support the entire academic exchange lifecycle.

4. Peking University Research Data Management Service Framework Design

4.1 Service Framework Design

To adapt to teaching and research transformation trends and the new data-intensive research paradigm, Peking University Library has made building a new academic exchange ecosystem its key development goal, establishing a data resource and RDM service framework (see Table 5) through platform development, services, training, and policy research. Organizational and resource development adjustments include: (1) renaming the former Systems Department to Information Technology and Data Center, establishing data management and service positions for comprehensive platform, tool, and service development; (2) establishing a Research Support Center with data librarians providing information literacy and data consultation; and (3) making data resources a core collection development component.

On December 25, 2015, Peking University officially launched four academic ecosystem services: the Open Research Data Platform, Institutional Repository, Open Publishing Journal Network, and Scholar Homepage, becoming a pioneer in domestic university implementations. In 2015, the library restructured to create dedicated RDM positions (see Table 4). Based on domestic and international surveys and user needs, the library designed its data management service framework system.

4.2 Peking University Research Data Management Service Practice

4.2.1 Data Services Peking University began investigating RDM in 2013, examining existing services (Harvard, Edinburgh, Monash, Fudan), policies (U.S. NSF, UK Research Councils), platforms (Dataverse, ICPSR, Data Conservancy, CKAN, Datahub), and persistent identifiers (DOI, Handle). Collaborating with the Social Sciences Department, Research Department, and relevant faculties, the library surveyed faculty needs and current practices through questionnaires and interviews. Based on these investigations, Harvard's open-source Dataverse system was selected to build Peking University's Open Research Data Platform.

In 2015, leveraging the NSFC "Peking University Management Science Data Center" project's "Data Services" subproject in collaboration with the Social Science Survey Center, the library built the platform using Dataverse 4.0 with customized features including bilingual interface, unified authentication, user

review management, DOI registration, and statistical functions, while the Survey Center drove dataset collection, organization, and publication. Launched in December 2015, the platform provides global users with research data submission, management, and open services. In 2016, platform data was linked with the institutional repository to enhance visibility and impact.

By October 2018, the platform had published 35 dataverses, 234 datasets, and 1,104 data files, including high-impact datasets such as the China Family Panel Studies, China Health and Retirement Longitudinal Study, Comprehensive Language Knowledge Base, and Chinese Biographical Database. The platform has achieved data exchange with Re3data and Data Citation Index (DCI), advancing toward an international-class service platform.

The 2017 Competition significantly enhanced platform influence while promoting data-driven research nationwide. During the competition, daily visitors averaged 753, dropping to 477 afterward—a nearly tenfold increase over pre-competition levels. Data downloads during the competition reached five times the total of the previous two years, with new user registrations four times the previous total. The second competition is underway in 2018, demonstrating that innovative services require innovative promotion methods.

A data services homepage is under construction to provide comprehensive service access, with professional data librarians offering consultation, literacy training, and resource navigation.

4.2.2 Data Management While international institutions primarily focus on data literacy and services, few provide data management during research processes, though this is precisely what researchers need. A 2017 University of Minnesota survey on Electronic Laboratory Notebooks (ELNs) at 35 top U.S. research universities found 23% had purchased ELNs, 40% used them in teaching or labs, and 20% of libraries provided ELN guides or webpages [38]. Peking University Library has begun developing data management tools, private cloud services, and process management platforms, providing research process data management through dedicated staff, platforms, and tools.

4.2.3 Data Literacy Since 2014, data librarians have conducted data literacy training through the library’s “One-Hour Lecture” brand, covering data resources, software tools, analysis/mining tools, and academic standards. In 2018, a data resource navigation was launched, providing access to 422 data resources by October 2018 [39]. The OCLC report specifically emphasized that data consultation must be face-to-face services provided by librarians.

4.2.4 Long-Term Preservation Peking University Library has prioritized digital resource long-term preservation as a key planning project, unifying self-built digital resources and data resources to construct preservation standards, specifications, and platforms. Integrated with research management systems

and university informatization projects, this will provide comprehensive long-term preservation services, with platform development underway and service launch planned for 2019.

4.2.5 Data Policy The team completed research, drafting, and validation of Peking University's open access policy for further revision and university submission. Data policies (national, funder, institutional, journal) are introduced through the One-Hour Lecture and data services homepage to help researchers navigate requirements. In October 2018, the Peking University Intellectual Property Information Service Center was officially established to build IP information resource platforms, conduct training, and provide full-lifecycle IP consultation for major research projects, supporting university-industry collaborative innovation and IP transfer.

4.3 Future Planning

Perfecting the RDM service framework and building a comprehensive service system to provide high-quality services and establish Peking University as a world-class leader in research data aggregation, management, and service is a key library development goal. Future efforts will strengthen research and application of data tools, software, management, and services to promote big data research and application. Accelerating research data construction, the library will use data services as a cohesive force to build a platform continuously aggregating high-quality domestic and international research data, providing teaching and research support. Data innovation research, teaching, and industry incubation activities and competitions will be conducted in partnership with government agencies and enterprises rich in data resources to seek complementary and win-win cooperation models, driving data teaching and research innovation.

In the big data and AI era, data-driven research methods have been applied across disciplines, making data-based research the trend. Emphasizing and developing research data management and services has become a crucial strategy for global research institutions to enhance academic competitiveness and influence. Following the State Council's 2018 Scientific Data Management Measures, Chinese funding agencies and research institutions will soon release data policies, making RDM services an important innovative library service. Libraries should understand RDM service frameworks, plan their service content, support data-driven research, and contribute to China's "Double First-Class" higher education construction and scientific innovation development.

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Author Contributions

Cui Haiyuan: Framework design, content writing, and revision;
Luo Pengcheng: Construction process content writing and revision;
Li Guojun: Research data management service homepage investigation content writing and revision;
Zhu Ling: Peking University research data service content writing.

Research and Implementation on Research Data Management Service Framework, Taking Peking University as an Instance

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Abstract: [Purpose/significance] Based on comprehensive investigation and study worldwide, this paper provides the research and service framework construction of research data management. It also introduces the experience of building research data management services of Peking University. It is hoped to help academic libraries to promote research data management services for data-driven research. [Method/process] By analyzing the demand on data services through faculty surveys in Peking University and investigating data ser-

vices in QS top 50 universities, it generalizes and designs the framework and contents of research data management services. By researching and designing the framework, it provides the framework of research data management services to academic libraries and introduces the experiences of building the research data management Services of Peking University. [Result/conclusion] The paper generalizes the framework as data management plan, data services, data management, data Literacy, data long-term preservation and data policy. It is hoped to help academic libraries to promote the development of research data management service and benefit for the improvement of open access and research innovation in China.

Keywords: data driven research, research data management, data service framework, data service, data policy

Note: Figure translations are in progress. See original paper for figures.

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