Functional Design of Library Digital Resources Standardized Procurement System (Postprint)

Authors: Wang Xueqin, He Juxiang

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Abstract

[Purpose/Significance] To establish a standardized digital resource procurement system with functional design, optimizing the digital resource procurement workflow and enhancing performance analysis capabilities for digital resource procurement and utilization. [Method/Process] Through a comprehensive review of theoretical research and practical developments in standardized digital resource procurement both domestically and internationally, utilizing literature research and practical analysis methods, this study analyzes the functional requirements for constructing a standardized digital resource procurement system from perspectives including digital resource lifecycle, resource types, and procurement workflow, and designs system functions across three dimensions: frontend, backend, and security. [Results/Conclusion] Based on the analysis of digital resource procurement processes, a procurement system encompassing five core functions—pre-procurement evaluation, procurement management, contract management, decision support, and basic management—is constructed, offering insights for the development of standardized digital resource procurement systems.

Full Text

Functional Design of a Library Digital Resources Standardized Procurement System

Authors: Wang Xueqin, He Juxiang
Affiliation: Southeast University Library, Nanjing 211189

Abstract:
[Purpose/Significance] This study aims to establish a digital resources standardized procurement system with functional design to optimize digital resources procurement workflows and enhance performance analysis capabilities for digital resources procurement and utilization. **[Method/Process]** Through reviewing theoretical research and practical developments in digital resources

standardized procurement both domestically and internationally, this paper employs literature research and practical analysis methods to analyze functional requirements for constructing a digital resources standardized procurement system from the perspectives of digital resource lifecycle, resource types, and procurement workflows, and designs system functions across three dimensions: front-end, back-end, and security. **[Result/Conclusion]** Based on analysis of the digital resources procurement process, this paper constructs a procurement system comprising five major functions: pre-purchase evaluation, procurement management, contract management, decision support, and basic management, providing insights for the development of digital resources standardized procurement systems.

Keywords: digital resources procurement system; standardized management; functional design

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In the context of internationalization and development in Chinese higher education, university libraries serve as resource and information centers. To support scientific research and academic development, their resource procurement budgets have shown annual growth. According to statistics from the Digital Resource Acquisition Alliance of Chinese Academic Libraries (DRAA), total digital resources expenditures across Chinese university libraries have exceeded ten billion yuan. Consequently, the standardized and normalized development of digital resources has become particularly critical. As a vital component, the implementation of standardized and normalized systems for digital resources procurement holds significant practical value. Such systems can standardize library digital resources procurement processes, save time costs, enhance work convenience and continuity, facilitate in-depth analysis of procured digital resources, and support discipline construction and library consortium development.

2 Research on Standardized Digital Resources Procurement in Libraries

2.1 Theoretical Research

2.1.1 International Research Status International development of digital resources standardization began earlier and is relatively mature. The National Information Standards Organization (NISO) in the United States has proposed a series of national standards for digital resources, among which the *Standardized Usage Statistics Harvesting Initiative* has been widely applied in e-book acquisition. In digital cataloging and discovery, the Dublin Core metadata standard is well-established, while the COUNTER statistics report and SUSHI protocol standard serve the digital statistics domain. Scholars have gradually explored policies and standards in digital acquisition. A.N. Mishra [1] examined the impact of digital procurement capabilities on procurement performance. British scholar C.J. Urquhart [2] proposed joint digital procurement between

the National Health Service and higher education in the UK, presenting three approaches: shared information and joint advocacy, establishing technical infrastructure, and joint procurement. O.S. Topcu [3] discussed the necessity of data integrity and standardization for information systems and libraries' long-term development, introducing constraints such as national regulations and language culture in Turkey's data standardization process.

2.1.2 Domestic Research Status Domestic resource construction standards have traditionally focused on traditional print resources, workflow management, and metadata management, supporting standards like MARC21 and Dublin Core. In recent years, the scope has gradually expanded to digital resources, where industry standards dominate and national standards are relatively few, mostly being localized versions of ISO standards without optimization or further updates based on local development. Standard content tends toward construction and organization of various digital resource types, with less involvement in standardization of library digital resources acquisition and management. The domestic library community has recognized the importance of digital resources standardization and normalization, organizing discussions from multiple perspectives including international cooperation and domestic research projects. Deng Shi et al. [4] introduced and analyzed NISO procurement standards from the United States. Li Lu et al. [5] introduced the origin, characteristics, and principles of US DDA acquisition standards and their platform support such as Alma. Yi Xiaoe et al. [6] introduced five foreign open-source electronic resources management systems capable of workflow management, acquisition functions, statistical functions, and interoperability. DRAA and the China Academic Library & Information System (CALIS) organized the 2018 BIBF China-US Digital Resources Standards and Specifications Seminar to discuss and share developments and practices in digital resources standards [7].

2.2 Development Practice of Next-Generation Library Management Systems

In the era of smart libraries, library business functions are becoming increasingly intelligent and digitalized. Libraries now manage not only print resources but also massive amounts of electronic resources, smart devices, learning spaces, institutional repositories, research data, and user data as new management objects. Next-generation library management systems have emerged based on reader needs and library requirements, characterized by two main aspects: (1) Functionally, traditional library management systems primarily handled acquisition, cataloging, and circulation of print resources and reader information management, whereas next-generation systems add digital resources management, enabling unified management of acquisition workflows and usage statistics for digital resources. (2) Technically, next-generation systems integrate with front-end resource integration platforms and discovery systems to better reveal various resource types, improve resource utilization, and enable analysis of big data on library resources and users to support library services and decision-making.

Currently, prominent next-generation library management systems include Ex Libris' Alma, Innovative's Sierra, SirsiDynix's Symphony, and OCLC's WMS. Domestically, no next-generation system has yet emerged. The Huiwen system, as a domestic library management system with high market share and long development history, has also made some innovative R&D efforts. Alma is a cloud-based next-generation library services platform supporting integrated management of print, electronic, and digital resources, covering comprehensive library operations. By early 2019, six institutions in China, including Tsinghua University Library and Beijing Institute of Technology Library, had introduced the system, but realizing its diverse functions still requires time for adaptation. Domestic management systems like Huiwen remain in traditional models, having not yet integrated digital resources workflow management, though they recognize the importance of digital resources management and have launched electronic resources access statistics systems while collaborating with EBSCO to develop integrated discovery systems for electronic resources [10].

Due to cost and compatibility factors, most universities have not yet introduced next-generation systems, and localized digital resources standardized procurement systems have not been established. University libraries still have considerable room for development and improvement in digital resources acquisition, management, and standardization. Domestic library digital resources management, particularly workflow management, remains a weak link. This paper discusses not the construction of a complete next-generation library management system, but rather an acquisition system that can achieve standardized interviewing of digital resources.

2.3 Functional Positioning of Library Digital Resources Standardized Procurement Systems

Based on practical work and relevant research, traditional library management systems focus on print resources procurement and related services, making it difficult to meet digital resources procurement needs. Current library digital resources procurement lacks mature procurement systems as support, resulting in cumbersome processes and insufficient standardized management. Compared with existing electronic resources management systems and next-generation library management systems, the digital resources standardized procurement system proposed in this paper has the following characteristics: (1) Standardization and normalization of digital resources procurement processes. While next-generation systems like Alma include procurement workflows for both traditional and digital resources, this system focuses more comprehensively on standardized management of digital resources procurement, which is significant for optimizing digital resources procurement processes. If successfully embedded into next-generation library management systems, it would enhance comprehensive capabilities in digital resources procurement, integration, discovery, and evaluation. Even as a standalone system, it would greatly improve library digital resources procurement efficiency and quality. (2) Summarizing system

requirements from practical perspectives to meet digital resources procurement needs and standardized management, aligning with current joint and individual procurement realities and different university libraries' digital resources procurement processes. (3) The procurement system comprises five modules with comprehensive functions and convenient design, high technical feasibility, and the ability to manage various types of digital resources including Chinese and foreign language e-journals, e-books, and databases.

3 Requirements Analysis for Digital Resources Standardized Procurement System

3.1 Standardized Management of Digital Resource Lifecycle

Requirements analysis forms the foundation for building a digital resources standardized procurement system. According to the *Electronic Resource Management Initiatives* (ERMI), the digital resource lifecycle can be summarized into several stages: trial period, procurement, cataloging and promotion, evaluation and renewal, and preservation. These stages essentially encompass the broad digital resources procurement workflow. The trial period includes user trial recommendations, supplier contact, trial application and activation, trial announcement and promotion, trial statistics and evaluation, feedback collection, and purchase recommendations. During this stage, libraries interact with suppliers, users, and evaluators, generating various types of information such as product introductions, trial reports, and emails that provide valuable references for subsequent digital resources advancement. The procurement stage, in the narrow sense, involves the business process of digital resources procurement, including bidding, sole-source certification, negotiation, licensing agreements, purchase content, purchase models, purchase terms, usage rights, contract formation, and payment—documents that hold important preservation value. The cataloging and promotion stage requires revealing and configuring purchased resources into the library's discovery system for one-stop user access while conducting multi-channel promotion and training for new resources to improve utilization. The evaluation and renewal stage primarily involves usage statistics, cost accounting, fault feedback analysis, and user satisfaction evaluation, with results serving as the main reference for renewal decisions. Currently, most foreign databases support COUNTER reports and the SUSHI protocol, though Chinese databases and some foreign databases have not yet produced standardized usage statistics—a consideration for standardized workflows. The preservation stage, as the final phase of the digital resource lifecycle, aligns with the characteristics of digital resources and their procurement models. Suppliers hold absolute ownership of their resources, with libraries typically obtaining usage rights rather than ownership. For most databases, annual payment only grants annual usage rights, making long-term preservation of purchased digital resources a problem that the library community needs to address.

3.2 Standardized Management of Different Digital Resource Types

Libraries procure diverse digital resource types, including e-journals, e-books, e-newspapers, numerical databases, index/abstract databases, and multimedia videos. A standardized procurement system must accommodate identification, integration, classification, preservation, and reuse of procurement information for different resource types. NISO's electronic resources standards and specifications, including *Demand-Driven Acquisition of Monographs*, *Presentation and Identification of E-Journals*, and *Information Exchange Formats* [11], provide standardized references for procuring different digital resource types. Different electronic resources vary in procurement content, format, and preservation methods. For e-books, "acquisition plus preservation" must be ensured, with localized preservation implemented during procurement. E-journal databases constitute a large proportion of purchased databases; due to their vast volume, complete preservation is difficult, so standardized integration, discovery, and one-stop access should be emphasized. For numerical or multimedia databases, given their content and format characteristics, emphasis should be placed on "acquisition plus utilization," focusing on usage and promotion during procurement. Libraries need to develop procurement requirements and rules suitable for their collection development and institutional disciplinary characteristics for different digital resource types.

3.3 Standardized Management of Procurement Workflow and Documents

The digital resources standardized procurement system should standardize and normalize procurement workflows. Key standardization elements include: (1) formulation of digital resources procurement policies; (2) establishment of digital resources procurement decision-making groups; (3) specific procurement operations including trial, procurement, usage statistics, and performance evaluation; and (4) standardized management of various documents generated during procurement.

Digital resources procurement policies form the foundation of procurement work and serve as procurement standards or specifications. Southeast University Library plans to formulate a *Digital Resources Development Policy* to comprehensively review digital resources procurement and collection development, and has already established *Detailed Rules for Electronic Resources (Databases) Procurement Under 200,000 Yuan* as a normative reference document. Digital resources procurement is a complex process requiring comprehensive consideration of institutional disciplinary development and collection structure, with top-level control. Moreover, procurement is not the work of a single librarian but requires comprehensive evaluation. Our library has established a professional Collection Development Committee, with a "Library Work Committee" composed of campus experts responsible for risk control in resource development, and a "Collection Development Committee" composed of in-house experts providing professional recommendations and resolutions on digital resources procurement,

addition, renewal, and adjustment.

Currently, no specialized management software exists for digital resources procurement, making it difficult to manage the massive data volume generated during the process, let alone summarize, compare, analyze, and reuse procurement data. After embedding procurement standards and management requirements, the most important function of a standardized procurement system is to meet procurement workflow needs. University digital resources use government-allocated funds that must be used scientifically, rationally, and in compliance with regulations under supervision. Due to digital resources' characteristics, sole-source certification procedures vary across universities, but the process must be completed—a trend for future digital resources procurement. Therefore, procurement workflows are increasingly standardized and complex. Whether workflows operate scientifically and conveniently while enabling unified management of various documents formed during trial and procurement for each database—including recommendation reports, trial reports, contracts, proposals, and prices—and facilitating comparison, analysis, and aggregation by database type or procurement year constitutes a basic requirement for procurement system standardization.

Digital resources performance evaluation requires analyzing price, usage, and resource quantity data. With numerous databases and extensive annual reporting data, simplifying statistical work allows librarians to focus on in-depth analysis and evaluation of digital resources content.

4 Functional Design of Digital Resources Standardized Procurement System

4.1 System Functional Structure Design

Based on the authors' digital resources acquisition work practice and literature research, the standardized procurement workflow for digital resources can be represented as Figure 1 [Figure 1: see original paper]. Centered on the digital resources procurement process, procurement operations mainly include comprehensive investigation and evaluation, resource purchase, and digital resources management and maintenance. Accordingly, the authors designed the functional structure and modules of the digital resources standardized procurement system, detailed in Figure 2 [Figure 2: see original paper]. The system takes the digital resources procurement process as its main line, comprising five components: pre-purchase evaluation, procurement management, contract management, decision support, and basic management. The pre-purchase evaluation, procurement management, contract management, and decision support constitute the standardized procurement system operation front-end, while basic management primarily serves back-end management. Through data sharing among subsystems, the system will effectively enable online digital resources procurement and achieve workflow-based, normalized, and standardized digital resources procurement operations.

4.2 Standardized Procurement System Operation Front-End

4.2.1 Pre-Purchase Evaluation Pre-purchase resource evaluation is a crucial procurement stage. This module standardizes and systematizes evaluation methods and criteria, trial organization and analysis approaches, completing assessments of digital resources' disciplinary relevance, resource quality, user types, and functional platforms. It automates functions such as user self-recommendations, subject librarian recommendations, and consortium procurement information push, supports libraries in customizing evaluation models, and provides data analysis support to enable decision-makers to predict resource procurement feasibility.

4.2.2 Procurement Management Based on procurement types, digital resources procurement can be categorized as new resource procurement, joint procurement (e.g., DRAA, JALIS), resource renewal, and independent negotiation procurement. According to the *Guidelines for Centralized Document Procurement in Regular Higher Education Institutions Libraries* formulated by the Steering Committee for Library and Information Work in Higher Education Institutions, digital resources procurement methods include procurement record-filing, sole-source negotiation, bidding, or competitive negotiation [12]. Current investigations show that Chinese university libraries generally adopt four methods: procurement record-filing, sole-source procurement, bidding procurement, and agreement-based procurement [13]. Different workflows should be designed for different procurement types and methods for categorized management.

Procurement management primarily includes procurement plan formulation, procurement scheme determination, resource negotiation, procurement approval, procurement progress tracking, and supplier management. In the standardized procurement system, the procurement plan formulation module supports libraries in managing digital resources renewal, addition, cancellation, or adjustment based on budget and requirements, enabling comparison between budgeted and actual database expenditures. The procurement scheme determination module enables design and confirmation of procurement schemes regarding resource types, years, or quantities, confirms procurement channels (national consortium, regional consortium, or independent negotiation), and compares duplication rates between proposed and existing resources, particularly for new resources. The resource negotiation module 主要针对非“团购”类数字资源, manages multiple rounds of important proposals, prices, responses, and decision opinions from both negotiation parties, as well as negotiation timelines. The procurement approval module allows procurement decision-makers to approve budget plans, procurement schemes, workflows, and expenditure processes. The procurement progress tracking module enables acquisition staff to track and query the entire procurement process in real-time, achieving comprehensive control over procurement budgets, fund usage, and scheme approvals. The supplier management module manages database suppliers' proposals, resource data, responses, and other information, as well as supplier

profiles themselves, thereby managing digital resource sources and improving database maintenance convenience.

4.2.3 Contract Management Digital resources involve numerous types and quantities, generating substantial contract documents during procurement, including consortium procurement schemes, license agreements, and payment contracts. The contract management module should implement contract formulation, approval, modification, archiving, expiration alerts, and statistical analysis, pushing information to relevant personnel in a timely manner to enable online contract signing, maintenance management, and execution status tracking. Additionally, the contract management module should interconnect with university financial systems, connecting to different payment processes for different procurement funds and managing payment information including amounts, purchase years, payment times, exchange rate specifications, and invoice management.

4.2.4 Decision Support Decision support requires the procurement system to provide database analysis and statistical functions based on relevant standards and business needs, enabling database statistics and performance evaluation. Combined with usage statistics, the system should evaluate database performance across dimensions including: (1) database usage statistics; (2) database prices and per-article usage costs; (3) comparisons with average and median usage costs across other universities; and (4) labor, time, and daily maintenance costs generated during procurement. Therefore, in evaluating digital resources usage effectiveness, the system should support manual data entry, import and analysis of COUNTER standard reports provided by database vendors, and automatic collection and harvesting of analysis data from databases supporting the SUSHI protocol. Using visual chart analysis technology, the system should provide descriptive statistical analysis (monthly/quarterly/annual database usage statistics, search/download/access volumes across databases, most-used databases, etc.), digital resources usage benefit analysis (cost per article, cost per login, cost per search, etc.), and after-sales evaluation (problem frequency, update speed, database usage training push, etc.), enabling authorized personnel to clearly understand digital resources procurement and usage effectiveness, effectively improving procurement quality and better meeting reader needs.

4.3 Standardized Procurement System Management Back-End

The system implements role-based and permission-based customization for procurement task executors, enabling hierarchical group management of internal user groups and assigning different access permissions based on staff responsibilities to ensure that personnel at different levels and groups can only browse and operate corresponding projects. Simultaneously, the system must adapt to organizational operational changes, achieving dynamic management of roles, permissions, and users. The structural model design of the basic management

subsystem is shown in Figure 3 [Figure 3: see original paper]. The main functional modules include:

(1) **User Management.** This manages the identity, roles, and permissions of various users logging into the system, logging and auditing login and operation processes.

(2) **Notification Management.** This manages trial notifications, information changes, etc., for procurement staff roles, fund management roles, system administrator roles, and regular account roles. Users are assigned different access permissions based on their roles, implementing multi-level access control to facilitate secure procurement operations. The user management module is based on Role-Based Access Control (RBAC) concepts and models.

(3) **System Maintenance.** This improves and expands system functions to enable permanent preservation of digital resources.

(4) **Data Backup and Recovery.** Using logical backup methods combined with full, incremental, and differential backup strategies, this implements backup of all data generated in digital resources standardized procurement (manual and automatic backup) to ensure rapid recovery from failures.

(5) **Log Management.** Based on the standardized procurement system's development language and platform, this establishes concise, graded log collection strategies to effectively record and securely store user access logs and system monitoring logs for important operations, facilitating later inspection, particularly for troubleshooting operational errors and tracing malicious attacks.

(6) **Exception Handling.** This implements designed exception handling mechanisms for potential network interruptions, server failures, and other situations during system operation, enabling real-time alerts and blocking of various risk and attack behaviors against databases. It achieves automatic identification, preliminary diagnosis, and handling of exceptional events, promptly reporting them to technical staff.

4.4 System Security

(1) **System Operating Environment Security.** According to university and library deployment requirements for management information systems, this configures firewall ports, secure encryption protocols for content transmission, etc., to ensure the physical and network security of the standardized procurement system's operating environment.

(2) **Data Storage Security (Localization).** The standardized procurement system generates substantial data during operation, including resource data, business process data, and user data. Based on the goal of long-term digital resources preservation and considering requirements

for different digital resource types (e-books, e-journals, numerical or multimedia databases) regarding content importance, data volume, and storage formats, different localization strategies should be formulated to safeguard libraries' permanent preservation of digital resources.

5 Implementation Elements of Digital Resources Standardized Procurement System

5.1 Policy Support

Currently, the digital resources standardized procurement system remains in the functional requirements stage, with implementation requiring multi-dimensional support. Literature searches on themes like "electronic resources + acquisition (procurement)" or "digital resources + acquisition (procurement)" reveal that the library community currently focuses on the combination of acquisition and management, primarily from an electronic resources management perspective, with limited emphasis on electronic resources standardization. Establishing a long-term ecological chain for digital resources acquisition or management requires protection and improvement from legal, policy, industry standard, and national standard perspectives. According to central government procurement policy requirements, digital resources must undergo bidding or sole-source certification. Therefore, digital resources acquisition must strictly follow relevant national policies to ensure scientific, fair, and legal acquisition work. Digital resources management involves substantial data; implementation of standards like COUNTER reports and the SUSHI protocol has improved standardization, normalization, and convenience of digital resources usage statistics. University libraries can automatically obtain database usage statistics through SUSHI protocol configuration. Whether libraries develop procurement systems independently or collaborate with technology companies, national and library industry policies and standards must serve as the basis for platform construction.

5.2 Funding and Technical Support

The digital resources standardized procurement system's development from functional requirements analysis and platform design to implementation requires funding and technical support. Alma's successful entry into the Chinese market comes at a high price far exceeding domestic traditional library management systems, making it unaffordable for most libraries regardless of functional effectiveness. Introducing existing next-generation library management systems is constrained by funding, while independent R&D is even more challenging. Traditional library management systems are mature but cannot meet the unified acquisition and management needs for electronic resources, multimedia resources, and other diverse resources. For libraries with strong funding and technical capabilities, independent R&D or collaboration with technology companies is possible, with libraries responsible for collecting and providing acquisition and user requirements. Southeast University Library (the authors' institution) has inde-

pendently developed or co-developed gift book management systems and foreign e-book management systems with good results: gift book management has become systematic and process-based for easy reference; the e-book management system has achieved localized preservation of purchased e-books, improving procurement performance. If each library independently develops digital resources procurement systems, it would inevitably lead to duplicated investment. Therefore, for most libraries, collecting functional requirements for digital resources procurement is the primary task, with gradual promotion through pilot implementations.

5.3 Practical Validation

Whether the digital resources procurement system can meet requirements needs continuous practical validation and revision. Libraries desire diverse and ideal functions. The standardized procurement system operation front-end appears procedural but actually requires high correlation among various data points. Meeting statistical, analytical, and comparative requirements across different databases and electronic resource types is not easy and requires validation with actual acquisition data. The massive volume of digital resources procurement data also requires validation of localization storage and security. Our library once trialed an electronic resources management system—an electronic resources utilization performance analysis platform—aiming to comprehensively evaluate and analyze all electronic resources. After local database configuration and SUSHI configuration, we found its functions were not as comprehensive and convenient as envisioned, still requiring manual involvement, with various statistics only serving as partial references.

The construction of digital resources standardized procurement systems requires multi-angle discussion and analysis from procurement standards, procurement requirements, procurement workflow management, and procurement evaluation and decision-making. The system discussed in this paper remains at the conceptual stage; the next step is R&D and practical validation. University library digital resources procurement work accounts for an increasingly large share, and its standardization, normalization, and convenience are urgent issues for the profession to address.

From initial requirements collection to functional design, this system revolves around actual conditions and functional needs in digital resources procurement processes, aligning with procurement practices and processes in most university libraries and enabling broad promotion and application. Meanwhile, university libraries' technical R&D capabilities continue to improve, with increasingly extensive and in-depth cooperation with external technology companies. Therefore, the digital resources standardized procurement system is both technically feasible and implementable and promotable in terms of requirements.

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Wang Xueqin: Conceptualization, framework design, data collection, practical investigation, writing and revision;
He Juxiang: Writing of partial sections and data collection.

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