Research on Electronic Resource Utilization in University Libraries from a Social Network Perspective: A Case Study of Fudan University Library (Postprint)

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Abstract

[Purpose/Significance] In the digital and information era, electronic resources have become increasingly prominent. Analyzing the characteristics of database usage across academic disciplines and departments facilitates the optimization of electronic resource development and advances the "Double First-Class" initiative in higher education institutions. [Methodology/Process] Using Fudan University Library as a case study, this research employs questionnaire surveys, social network analysis, and the Leiden clustering algorithm to explore the correlations between academic disciplines, departments, and the utilization of library electronic resources. [Results/Conclusion] Cohesive subgroups exist in the utilization patterns of electronic resources among disciplines and departments, and the advancement of interdisciplinary studies promotes the use of cross-disciplinary specialized databases. Going forward, university libraries' electronic resource development may reference the correlation and clustering characteristics of disciplines and departments in resource utilization, integrate the widely adopted COUNTER usage statistics methodology, optimize electronic resource allocation and procurement from multiple dimensions, and innovate the developmental trajectory of subject services.

Full Text

Preamble

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Abstract:
[Purpose/Significance] In the digital and information age, electronic resources have become increasingly prominent. Analyzing the characteristics of database usage across academic disciplines and departments can help optimize electronic resource development and promote the construction of "Double First-Class" universities in China. [Method/Process] Taking Fudan University Library as a case study, this paper employs questionnaire surveys, social network analysis, and the Leiden clustering algorithm to explore the relationships among disciplines, departments, and library electronic resource utilization. [Result/Conclusion] The study reveals that cohesive subgroups exist in the utilization of electronic resources across disciplines and departments. The development of interdisciplinary research promotes the use of specialized databases across different fields. Future electronic resource development in university libraries should consider the relational and clustering characteristics of disciplines and departments in resource utilization, combined with the commonly used COUNTER usage statistics methodology, to optimize resource allocation and procurement from multiple dimensions and innovate the direction of disciplinary services.

Keywords: social network analysis; electronic resources; Leiden algorithm; cluster analysis; resource development
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Since the release of the "Overall Plan for Coordinating the Construction of World-Class Universities and First-Class Disciplines" [1], the development of first-class disciplines has become a critical component of university reform in China. University libraries can provide strong support and services for disciplinary development, while "collection" and "utilization" represent the fundamental conditions for library survival and development [2]. Electronic resources in university libraries provide stable literature support for teaching and scientific research. According to incomplete statistics from the Ministry of Education's University Library Committee, the proportion of funding invested in electronic resource development has been increasing annually, reaching approximately 60% of total literature resource development expenditure by 2018 [3], with some institutions even reaching 80%-90% [4].

In the post-pandemic era, electronic resources have increasingly become a crucial strategic resource for library transformation [5]. Evaluating electronic resources and optimizing their development has become a core task in the current development of university libraries.

1 Current Status of Electronic Resource Evaluation Research

Evaluation indicator frameworks for electronic resources have been established through various methods [7], and demand-oriented resource evaluation and procurement strategies have been developed by mining user needs through statistical analysis of electronic resource usage, questionnaires, researcher discussions, and expert consultations [8]. Southwest University Library categorizes evaluation indicators into three major categories: usage cost, resource quality, and resource effectiveness, assigning higher weight to resource effectiveness to prioritize meeting user needs and institutional development requirements [9].

Incorporating user data dimensions into electronic resource evaluation has become a focal point in the library community both domestically and internationally. A "user utilization" orientation helps optimize electronic resource development and enhance user satisfaction. Zan Dong and Pang Ping [10] propose adding user feedback indicators to electronic resource evaluation to establish a demand-driven resource development model. Bi Yanfang and Li Taifeng [11] construct a digital resource evaluation model based on user data, assessing library resource service value through user information behavior data, teaching and research activity data, and user social activity data. In electronic resource evaluation at Xiamen University, in addition to content analysis and statistical indicators, dimensions such as user ratings and feedback, scores from subject librarians and electronic resource acquisition librarians, and written arguments are included [12].

Research on electronic resource usage and user needs analysis helps libraries better formulate procurement plans and meet user needs, maximizing resource utilization. Currently, libraries primarily rely on statistics obtained from database vendors [13] and Web log analysis [14-15] to understand electronic resource usage data. The commonly used data collection standard is the Counting Online Usage of Networked Electronic Resources (COUNTER) project [16-17]. Since the release of its first version in 2002, it has undergone continuous upgrades and integration, officially launching COUNTER Release 5 in January 2019 [18]. Foreign database vendors have widely adopted the COUNTER standard, and libraries can obtain electronic resource statistical reports through the Standardized Usage Statistics Harvesting Initiative Protocol (SUSHI). However, COUNTER generally only provides institution-wide usage statistics, making it impossible to conduct in-depth analysis by discipline or department. Moreover, among domestic databases in China, only CNKI provides usage statistics based on the COUNTER standard; other Chinese database vendors have not adopted this standard and lack uniform standards [19-20].

Individual usage data can be obtained through analysis of user electronic resource access logs. The University of Electronic Science and Technology of China Library uses statistical data from its in-house database traffic monitoring system as user data for electronic resources that cannot provide standardized

statistics [11]. Liu Hui et al. [21] collect data on user behavior characteristics such as URL page visits, browsing, searching, and downloading to create user profiles analyzing user interests and needs for electronic resources. Luo Mengru and Yuan Xiaoyi [19] propose a "user + library + resource vendor" behavior data acquisition model based on localized user authentication access to achieve precise correspondence between behavior data and users. Ni Chong [22] concentrates some digital resources on a single server to provide access services for users and obtain user access statistics. However, due to the complexity of network access to electronic resources and the diversity of resource types, research on electronic resource usage behavior data of university users remains in the exploratory stage, with no mature models or products available for the library community.

[Figure 1: see original paper] shows the social network-based electronic resource evaluation model.

2 Data Sources and Research Methods

2.1 Data Sources

We obtained user information on library electronic resource usage through questionnaire surveys. The questionnaire primarily included three sections: basic personal information, electronic resource usage, and opinions/suggestions, totaling 13 questions. The survey targeted individual databases/platforms, including some commonly used OA resources. Database usage data was based on survey respondents' selection and ranking of databases, including both comprehensive and specialized databases. The survey was conducted from October 14 to October 30, 2020. Questionnaire links were sent to users via the Fudan University Library email service system, resulting in 1,733 completed questionnaires. After data cleaning, 1,509 valid questionnaires were obtained, with an effective response rate of 87.07%. Among respondents, undergraduates accounted for the largest proportion at 38.17%, followed by master's students (23.33%), doctoral students (31.01%), and faculty, researchers, and postdoctoral fellows (6.43%).

The cost calculation method for abstract databases such as Web of Science, Scopus, and Engineering Village was based on search statistics provided by database vendors and corresponding annual subscription fees to calculate cost per search.

2.2 Research Methods

2.2.1 Social Network Analysis Social network analysis is a tool for studying interaction relationships and structural characteristics among entities in networks [31-32], which can be used to depict usage relationships between user departments and databases, constructing a department-database usage network. We used the open-source data visualization software Gephi 0.9.2 as the analysis tool for complex networks. Departments and databases were selected as network

nodes, with usage relationships between departments and databases serving as network edges directed from departments to databases. The PageRank algorithm was employed to calculate node influence in the department-database usage network. The PageRank index utilizes the relational structure of data to calculate each node's "importance" in the global network, more accurately reflecting node influence [33]. According to the PageRank index, a node's importance depends not only on its own degree but also on the importance of connected nodes. The PageRank index calculation formula is [34]:

$$PR(i) = (1-d) + d\sum_{j\in n}\frac{PR(j)}{N(j)}$$

Where $PR(i)$ represents the PageRank index of node i; d is the damping coefficient, typically set at 0.85 [35]; n is the set of all other nodes connected to node i; $N(j)$ is the degree of node j; and $PR(j)$ represents the PageRank index of node j.

2.2.2 Cluster Analysis This study used the Leiden algorithm developed by V. Traag [36] in 2018 to cluster the department-database usage network and obtain affinity relationships between databases and departments. Compared with the widely used Louvain algorithm in network analysis, the Leiden algorithm offers faster processing speed and higher clustering precision [37], facilitating the identification of optimal clustering sets. In clustering results, objects with high similarity are grouped into the same class or cluster, while objects from different classes exhibit high dissimilarity. The Leiden algorithm source code can be downloaded from GitHub (https://github.com/vtraag/leidenalg). Clustering results can be visualized using Gephi.

3 Results Analysis

3.1 Department-Database Usage Network

Based on survey respondents' departments and their selected databases with high dependency levels, we used Gephi to map the Fudan University department-database usage relationship network, employing the ForceAtlas force-directed layout algorithm (Figure 2). In this layout, nodes at the center position represent the center of all nodes [38], allowing identification of influential nodes in the relationship network.

In the department-database usage network, triangular nodes represent departments, and circular nodes represent databases. Edges represent survey respondents (departments) selecting a particular database, with direction from department to database. Edge thickness corresponds to the number of users from a department selecting that database, while node size is proportional to its PageRank index. The network contains 152 nodes and 1,784 edges. A total of 38 departments participated in the survey, with users selecting 114 databases.

Table 1 shows parameters for high-influence nodes in the department-database relationship map. “Department count” refers to the number of user departments selecting that database in the questionnaire, “weight” indicates the total number of survey respondents selecting that database, and the PageRank index is the metric for determining node importance [39].

As shown in Figure 2 [Figure 2: see original paper], the central positions in the relationship network are primarily occupied by comprehensive databases such as VIP, Superstar Digital Library, CNKI, Wanfang, Web of Science, Elsevier, ScienceOnline, Springer, and Nature. These comprehensive databases also rank at the top in terms of network influence (see Table 1). Notably, 1,115 faculty and students from 38 departments selected CNKI in the questionnaire, with its PageRank index far exceeding other databases.

It is worth noting that although Scopus is a comprehensive database, it occupies a peripheral position on the right side of the department-database usage relationship network. Scopus's PageRank index is only 0.00636, significantly lower than other central comprehensive databases (see Table 1). This indicates Scopus has weaker influence and lower usage among questionnaire respondents. Engineering Village, an engineering-focused comprehensive database, also occupies a peripheral position on the right side of the network. Compared with other abstract databases such as SciFinder, Scopus, and Web of Science, Engineering Village's PageRank index is also low at 0.00562, indicating weak influence. Fudan University focuses primarily on liberal arts, sciences, and medicine, with fewer engineering disciplines. The university's disciplinary characteristics have thus influenced Engineering Village's usage patterns.

Comparing database usage statistics, both Scopus and Engineering Village at Fudan University had very high per-use costs in 2019, over 46 times higher than Web of Science. This analysis further confirms that Scopus and Engineering Village have lower utilization rates than most comprehensive and abstract databases, which is the primary reason for their high costs.

Figure 2 shows that specialized databases generally cluster around relevant departments; the higher the relevance between a database and department, the closer their distance. For example, law-related databases such as Beida Fabao, Wolters Kluwer, Wanlv, WestlawNext, and HeinOnline are positioned near the Law School. Similarly, chemistry-specific databases such as ACS, RSC, SciFinder, and Reaxys are positioned near the Chemistry, Macromolecular Science, and Materials Science departments.

3.2 Leiden Algorithm Cluster Analysis

Cluster analysis examines departmental behavior characteristics in database utilization to analyze database demand structures and cohesive subgroups, thereby facilitating electronic resource promotion and development optimization. In the electronic resource usage network, a community refers to groups connected through the department-database usage relationship network, forming cohesive

subnetworks.

We conducted cohesive analysis of the department-database usage network using the Leiden community detection algorithm, with visualization results shown in Figure 3 [Figure 3: see original paper] and detailed clustering results in Table 2 . Based on database utilization patterns, departments and databases with strong correlations cluster together to form communities.

As shown in Figure 3 and Table 2, the Leiden algorithm clustering results divide the department-database usage network into four communities:

Community 1 primarily consists of humanities and social sciences departments and specialized databases, including the School of Management, School of International Relations and Public Affairs, School of Economics, Department of History, School of Journalism, School of Philosophy, Department of Chinese Language and Literature, and the Department of Atmospheric and Marine Sciences. The inclusion of the Department of Atmospheric and Marine Sciences occurs because atmospheric science research combines natural and social sciences [40], such as atmospheric environment and global climate change, atmospheric chemistry, and environmental policy research [41]. Survey respondents from this department selected 26 databases, with over half being humanities and social sciences databases.

Community 2 includes engineering and medical departments such as Environmental Science and Engineering, Chemistry, Materials Science, Life Sciences, and Medicine, along with specialized databases in chemistry and medicine.

Community 3 comprises science and engineering departments such as Computer Science, Information Science and Engineering, Software, Mathematics, Physics, and Big Data, along with specialized databases in these fields.

Community 4 consists primarily of the Law School and law-related databases.

In Figure 3 [Figure 3: see original paper], specialized databases such as the Inter-University Consortium for Political and Social Research (ICPSR), Independent Scholarly Publishers Group (ISPG), and Karger are not positioned near their corresponding departmental nodes, instead appearing at relatively distant positions within their communities or even in other communities.

To further analyze these patterns, we mapped partial department-specialized database usage networks using Gephi, as shown in Figure 4 [Figure 4: see original paper]. The Rockefeller University Press Journals database, which includes three biomedical journals, was selected exclusively by users from Fudan University's School of Microelectronics (see Figure 4). The ISPG database, covering medicine and life sciences, was not selected by any surveyed users from medical or life sciences departments; instead, users from the School of Microelectronics and Department of Information Science and Engineering chose this database.

This phenomenon reflects two factors: first, the development of interdisciplinary research leads researchers to use specialized databases from other disciplines or

employ new methods for research topics requiring other professional databases. For example, research at Fudan University's School of Microelectronics includes artificial synapse simulation using novel electronic/optoelectronic devices [42] and flexible brain-like neural networks [43], representing close integration between microelectronics and biomedical research. Surveyed users from the School of Microelectronics selected 49 databases, including seven specialized biomedical databases. Second, it indicates that biomedical users may not be aware of this database; despite its biomedical content, they prefer other specialized databases they are accustomed to using.

The Karger database, in addition to medical users, was also selected by users from the School of Management and Department of Atmospheric and Marine Sciences, driven by interdisciplinary research on atmospheric environmental risks and public health governance [44], air quality, and environmental management and policy studies. ICPSR, the world's largest social science data archive, was selected by users not only from economics, management, and philosophy departments but also from the Department of Macromolecular Science and School of Basic Medical Sciences. In addition to these databases, others such as the American Physiological Society (APS) and China InfoBank also exhibit clear cross-disciplinary usage patterns, as detailed in Table 3 .

In contemporary scientific research, major complex problems cannot be solved through single-discipline knowledge and methods alone. Interdisciplinary integration and deep fusion have become important trends in modern scientific development [45-46], bringing about cross-disciplinary usage of specialized databases.

4 Conclusions and Recommendations

Electronic resource usage statistics and evaluation are crucial data foundations for resource development and disciplinary services [19]. This study employs questionnaire surveys, social network analysis, the PageRank algorithm, and Leiden clustering to construct a user demand-driven database evaluation method, conducting precise analysis of electronic resource usage at Fudan University Library from disciplinary and departmental perspectives. The results can serve as supplementary references to quantitative usage statistics, combining qualitative and quantitative analysis to provide evidence for library electronic resource development strategies and disciplinary service initiatives.

Using social network analysis and questionnaire surveys to study departmental and disciplinary database usage behavior reveals supply-demand relationships in electronic resources through visual mapping. Combining database usage statistics with user demand research, qualitative evaluation can supplement quantitative statistics to formulate electronic resource rating indicators and optimize database subscription levels. This approach is particularly valuable for databases without COUNTER statistical standards, as the calculated PageRank indices provide important references for assessing electronic resource support levels.

Through cluster analysis of the department-database usage network, departments and databases with similar usage behaviors form cohesive subgroups. In electronic resource development, departments or disciplines within the same community can consider joint development and shared usage. Cohesive communities can also reveal cross-disciplinary usage patterns of specialized databases, helping to understand how interdisciplinary development affects user behavior and needs. This can expand the scope of departmental representation on electronic resource advisory committees, refine user feedback collection, enable precise electronic resource information dissemination, and improve database trial recommendations.

Based on disciplinary clustering characteristics and a "user utilization" orientation, libraries can optimize electronic resource development and deliver precise disciplinary services. Research results can serve as supplementary references for database importance evaluation, combined with usage statistics, cost accounting, and content analysis to provide effective, comprehensive, and intuitive data support for library resource development and disciplinary services. However, this study did not conduct more detailed analysis of database usage behavior in individual disciplines; future research could combine user interviews and resource development committee discussions to construct refined, multi-dimensional, and multi-level disciplinary resource development models, supporting the construction of "Double First-Class" universities.

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Yang Xin: Data collection and analysis, manuscript writing;
Zhang Min: Topic selection, guidance on manuscript writing, manuscript revision;
Liao Jianlan: Topic selection, data collection and analysis, manuscript revision;
Shao Chengmin: Guidance on manuscript writing, manuscript revision.

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