Knowledge Graph-Based Review of Domestic Data Literacy Research: Postprint

Authors: Li Jiaojiao, Yang Zhihe

Date: 2023-10-08T00:00:00+00:00

Abstract

[Purpose / Significance] To understand the current state of domestic data literacy research and systematically review its research themes, content, and development trends.

[Method / Process] Grounded in co-word analysis theory, this study employs cluster analysis and strategic coordinate analysis to construct a knowledge map and strategic coordinate diagram of data literacy research themes, visualizing the results.

[Results / Conclusion] Data literacy research is in the exploratory stage, with diversified content broadly divided into eight themes that are interrelated and mutually reinforcing. Future research trends may advance toward library data literacy education and data literacy among next-generation librarians.

Full Text

A Review of Data Literacy Research Based on Knowledge Map in China

Li Jiaojiao[1], **Yang Zhihe**[2]
[1]China Academy of Information and Communications Technology, Beijing 100080
[2]School of Information Management, Heilongjiang University, Harbin 150081

Abstract:
[Purpose/Significance] This study aims to understand the current status of data literacy research in China, and to systematically review the thematic content and development trends in this field. [Method/Process] Grounded in co-word analysis theory, we employed cluster analysis and strategic coordinate analysis to construct a knowledge map and strategic coordinate diagram of data literacy research themes, presenting them through visualization. [Result/Conclusion]

The findings indicate that data literacy research in China is in an exploratory stage with diversified content that can be broadly categorized into eight research themes. These themes are interrelated and mutually reinforcing. Future research trends are likely to focus on library data literacy education and data literacy among a new generation of librarians.

Keywords: data literacy; knowledge map; co-word analysis; strategic coordinate analysis

1. Introduction

In 2007, E. Stevenson and colleagues formally introduced the concept of data literacy, identifying "finding, evaluating, and using information rationally and effectively" as its core elements [1]. Huang Ruhua and colleagues expanded the definition beyond data capabilities such as collection, representation, and description to include data awareness and data ethics [2]. Meng Xiangbao and others emphasized that data literacy requires researchers to possess judgment, analysis, and transformation skills regarding data itself [3]. In recent years, data literacy has become a hot topic in library and information science research. To understand the current state of domestic data literacy research and map its thematic content and development trends, this study employs co-word analysis theory, utilizing cluster analysis algorithms and strategic coordinate analysis to construct and visually present a knowledge map of data literacy research themes, providing references for the future development of data literacy education in the field.

2. Research Framework and Methodology

Based on the CNKI database, we selected journals indexed in CSSCI (Chinese Social Sciences Citation Index) and the *Catalogue of Chinese Core Journals* as our data sources. The research process involves six steps (see [Figure 1: see original paper]): (1) obtaining the literature dataset and extracting keywords; (2) processing data by merging similar keywords and removing irrelevant terms to obtain a keyword dataset; (3) constructing a keyword co-occurrence matrix based on the processed dataset; (4) implementing topic clustering and visualization using the Smart Local Moving (SLM) algorithm; (5) calculating the centrality and density of each theme based on clustering results to construct a strategic coordinate diagram for analyzing relationships among themes; and (6) analyzing research trends.

Co-word analysis, proposed by M. Callon et al., is a content analysis method that reflects the main content of texts through word co-occurrence patterns [4][5]. Cluster analysis, first introduced to anthropology by H. E. Driver and A. L. Kroeber in 1932, is an unsupervised learning algorithm that groups similar research objects based on the principle that "like attracts like" [6]. This

study employs the SLM algorithm through VOSviewer 1.6.16 software for topic clustering [7].

Strategic coordinate analysis, proposed by J. Law et al., analyzes relationships among research themes and their developmental stages within a specific field [8]. The strategic coordinate diagram is the primary visualization tool—a two-dimensional chart with centrality on the x-axis and density on the y-axis. For a given theme cluster, centrality represents the strength of connections with other theme clusters, while density represents the strength of internal connections among terms within the cluster [9]. The calculations are as follows:

$$C(k) = \sum_{i=1}^{n_k} \sum_{j=1}^{N} c_{ij} \quad (1)$$

$$D(k) = \frac{\sum_{i=1}^{n_k} \sum_{j=1}^{n_k} c_{ij}}{n_k} \quad (2)$$

where $D(k)$ is the density of theme cluster k, $C(k)$ is the centrality of theme cluster k, n_k is the number of keywords in theme cluster k, N is the total number of keywords in the co-occurrence matrix, and c_{ij} represents the co-occurrence frequency of keywords i and j.

Based on each cluster' s centrality and density values, we construct a strategic coordinate diagram (see [Figure 2: see original paper]). Themes in the first quadrant have high density and centrality, indicating strong internal connections and close relationships with other themes—these are core and mature research topics. The second quadrant contains themes with high density but low centrality, representing mature but peripheral topics with weak inter-theme connections. The third quadrant includes themes with low density and centrality, indicating peripheral and immature topics that may be either declining or emerging. The fourth quadrant comprises themes with low density but high centrality, representing core but immature topics with significant development potential [11][12].

3. Data Acquisition and Analysis

3.1 Data Source and Processing

Using the search term "data literacy" in CNKI' s advanced search function, we selected journals from CSSCI and the *Catalogue of Chinese Core Journals* without time restrictions. The search was conducted on September 2, 2021, yielding 401 results. After removing news reports, call for papers, and irrelevant literature, we obtained a final dataset of 395 articles.

3.2 Publication Volume and Citation Analysis

Temporal analysis of academic publications reveals the annual output in a specific field, helping to identify scientific development patterns and trends. We analyzed the publication volume and total citation frequency of data literacy research over time. As shown in [Figure 3: see original paper], domestic data literacy research in China began around 2013. From 2014 to 2016, both publication volume and total citations increased rapidly, reaching 53 publications and 1,227 total citations in 2016. After 2016, publication growth slowed but showed significant increases again after 2019. Overall, in an era of explosive data growth, data literacy research is in a developmental phase.

3.3 Data Literacy Research Theme Analysis

We extracted keywords with frequency $ $5 and employed co-word analysis and clustering techniques to create a visualization of domestic data literacy research themes. Using VOSviewer for cluster analysis and visualization (see [Figure 4: see original paper]), we identified eight research themes: (1) data literacy education for researchers, (2) data literacy education for data librarians, (3) data literacy education for teachers, (4) scientific data management, (5) data literacy competency evaluation, (6) library data literacy education, (7) data literacy education in library and information science, and (8) data literacy education in the big data era.

Theme 1: Data Literacy Education for Researchers. This theme is characterized by keywords such as data literacy education, information literacy, quality education, information retrieval, libraries, data science, teaching models, structural equation modeling, and analytic hierarchy process. Researchers have evaluated data literacy education for researchers, noting that foreign university libraries provide personalized data literacy education for researchers at different levels and in different fields, while domestic university libraries still focus primarily on traditional information literacy education without systematic data literacy programs [13]. Liang Yu and colleagues used qualitative research based on grounded theory to analyze factors influencing doctoral students' data literacy education from data, student competency, and environmental dimensions [14]. Hui Gongjian and others compared professional data literacy competency models, civic data literacy competency models, and student data literacy competency models to develop a content and structural model for student data literacy, constructing an evaluation index system across four dimensions: awareness, knowledge and skills, thinking, and ethics [15].

Theme 2: Data Literacy Education for Data Librarians. Core keywords include university libraries, academic libraries, talent cultivation, subject librarians, data librarians, digital humanities, and data services. Researchers have analyzed data librarians' work content and service methods from different perspectives and through various case studies. Gu Liping and colleagues analyzed job postings for data librarians in academic libraries to extract work

content and service methods in research data management services, proposing data literacy education content based on the research data lifecycle, such as data discovery and data usage capabilities [16]. Zhang Lu and others investigated foreign data librarian training practices and suggested that China should place greater emphasis on data literacy education, develop training resources, and strengthen cooperation [17]. Li Mei analyzed data management and services at the University of Edinburgh, describing data librarians' characteristics as requiring professional data capabilities, collaboration skills with high-level researchers, and teamwork abilities [18]. Other scholars have explored the professional skills and career development of data or subject librarians [19][21].

Theme 3: Scientific Data Management. This theme includes keywords such as scientific data, scientific data management, data curation, data management, data privacy, data security, data sharing, data management services, data lifecycle, research data, and researchers. On one hand, researchers have explored the status of research data management services in domestic and foreign universities from dimensions of data management knowledge, data security awareness, and data management skills. On the other hand, researchers have analyzed the scientific data literacy required by researchers at various stages of the research lifecycle [22]. Additionally, drawing on foreign scientific data management institutions' practical experience, researchers have proposed that China' s social science data management should emphasize data reuse and sharing, formulate relevant policies, coordinate planning of scientific data management institutions at all levels, and promote scientific data literacy education [3].

Theme 4: Data Literacy Competency Evaluation. This theme is represented by keywords such as university libraries, educational data, educational functions, education evaluation, data-intensive research, data analysis, data mining, and data quality. Research on data literacy education evaluation primarily focuses on university and public libraries. Based on H. D. Lasswell' s "5W" model, researchers have evaluated data literacy education from five dimensions: Who (subject), What (content), Whom (object), Which channel (method), and What effect (outcome) [23]. Zhu Jing and others constructed a public library data literacy education system from perspectives of objectives, objects, content, models, and evaluation [24]. Zhang Changliang and colleagues compared three Chinese and three American universities, analyzing differences in objectives, content, methods, and evaluation systems, and proposed that China' s data literacy education should provide personalized education for different groups, enrich training content, and strengthen multi-faceted cooperation [25]. Pan Xue and others constructed an evaluation index system for university library data literacy education based on the "5W" model [26].

Theme 5: Library Data Literacy Education. This theme includes keywords such as scientific data literacy, data literacy competency, education system, teaching decision-making, index system, and teachers. Research in this area covers university library data literacy education, public library data literacy education, and educational institution data literacy education, with uni-

versity library data literacy education being the primary focus. Wu Aizhi and others investigated domestic university library data literacy education forms, using Peking University Library as a case study to propose content and systems covering data ethics, data acquisition, data processing, data preservation, and evaluation/citation [27]. Zhang Wenliang and others examined foreign data literacy education status and, considering China' s actual conditions, proposed a framework for university library data literacy education from perspectives of target audience, structure, and content [28]. Xiao Ximing and others compared LIS education institutions with doctoral programs in China and the US, analyzing curriculum content, training awareness, and training intensity, and suggested that China' s LIS education should strengthen data awareness, build comprehensive data literacy education systems, and enhance interdisciplinary cooperation [29].

Theme 6: Teacher Data Literacy Education. This theme uses keywords such as teacher data literacy education, teacher professional development, primary and secondary school teachers, data application, data thinking, data awareness, data skills, data-driven teaching, evaluation indicators, factor analysis, and Delphi method. Research includes studies on foreign teacher data literacy education, evaluation of teacher data literacy education, and teacher career development. Li Qing and others investigated foreign teacher data literacy training programs, analyzing forms and content, and proposed that teacher data literacy should be developed at three levels: government, school, and individual teacher [30]. They also constructed a teacher data literacy competency model from knowledge and skills, teaching practice, and teaching inquiry dimensions [31]. Additionally, research on data literacy education for primary and secondary school teachers has become a focus, including studies on education content [32], evaluation systems [33], and development paths and strategies [34].

Theme 7: Data Literacy Education in the Big Data Era. This theme is represented by keywords such as big data, artificial intelligence, big data analysis, data literacy, educational informatization, educational governance, data journalism, smart education, and precision teaching. Researchers have begun exploring data literacy education content, training paths, and evaluation index systems in big data environments. Hui Gongjian and others analyzed existing domestic and international data literacy competency models to construct a student data literacy competency model for the intelligent era from perspectives of data ethics, data awareness, data skills, and data thinking, proposing an evaluation index system [15]. Xu Yafeng and others proposed that teachers should possess AI-based digital intelligence literacy in human-computer collaborative teaching environments, and identified components, mechanisms, and training methods from knowledge and skills, thinking ability, and ethical perspectives [35].

Theme 8: Data Literacy Education in Library and Information Science. This theme includes keywords such as library and information science education, information literacy education, government data, open data, training

paths, coping strategies, and big data era. Researchers have begun exploring development paths for data literacy education in LIS. Huang Ruhua and others explained the origin and connotation of data literacy in the big data context based on current academic and practical research, proposing that data literacy education content, subjects, objects, and forms are becoming more diversified [3]. Si Li and others investigated data literacy courses in 138 LIS programs at 38 institutions, analyzing curriculum content from data ethics, data skills, and data awareness layers, finding that data literacy courses in LIS are becoming more systematic, with data mining courses for big data processing technologies developing rapidly [36]. Zhou Linxing and others investigated data literacy courses in domestic university LIS programs, constructing optimization strategies for graduate data literacy education in big data environments from perspectives of disciplinary and social development needs, curriculum system construction, and data and social resources [37].

3.4 Strategic Coordinate Analysis of Data Literacy Research Themes

Based on the eight themes discussed in Section 3.3, we calculated each theme' s centrality and density using formulas (1) and (2) (see). We then plotted the strategic coordinate diagram with centrality as the X-axis and density as the Y-axis, using the mean values as the origin (see [Figure 5: see original paper]).

Centrality represents the strength of relationships among data literacy research themes—the higher the centrality, the closer the relationship with other themes and the more central the theme is to the field. Density represents the internal cohesion of a theme—the higher the density, the stronger the internal connections and the more mature the theme. According to the strategic coordinate diagram (see [Figure 5: see original paper]), from a global perspective, "Data Literacy Education for Researchers" (Theme 1) and "Data Literacy Education in the Big Data Era" (Theme 7) have high centrality values, indicating close connections with other themes and occupying core positions in the field. The density values across themes are similar, suggesting that all themes remain in an exploratory stage.

From a local perspective, Theme 1 and Theme 7 are located in the first quadrant, representing mature and core research themes with strong internal connections and close relationships with other themes, making them current hotspots. Theme 3 ("Scientific Data Management") is in the second quadrant, representing a mature but peripheral theme with strong internal connections but weaker relationships with other themes. Themes 2, 4, 5, 6, and 8 are in the third quadrant, representing immature and peripheral themes with sparse inter-theme relationships and loose internal structures. However, with continuous digital technology development and application, these may become emerging research topics.

4. Future Research Trends in Data Literacy

Based on the thematic clustering and strategic coordinate analysis results, future domestic data literacy research will likely focus more on data literacy education. The eight themes can be summarized into five categories: subject, object, objective, effect, and environment, which constitute the core elements of future data literacy education.

Libraries and Library and Information Science as Subjects Driving Data Literacy Education. Under the previous information age paradigm, library and information science disciplines were the main subjects for information literacy cultivation in China. Although we have entered a new digital economy era driven by next-generation information technologies, data literacy' s connotation and extension are much broader than traditional information literacy. According to the *Outline for Enhancing Citizens' Digital Literacy and Skills* released by the Central Cyberspace Affairs Commission on November 5, 2021, data literacy represents a deeper exploration and implementation of citizen information literacy from the information age. This requires more groups previously engaged in information literacy education to focus on building data literacy cultivation systems for digital transformation across all industries. Current and future digital transformation undoubtedly requires broad improvement in citizens' data literacy, assigning library and information science professionals the mission to develop specialized data literacy education.

Data Librarians, Researchers, and Teachers as Main Objects of Data Literacy Education. Libraries serve as both vehicles for social services and primary objects of data literacy education. Data literacy education is an important function of all types of libraries, with data librarians being crucial carriers for libraries' social services in the digital era. From the "data-to-information" service logic, all personnel engaged in digital transformation—including researchers and teachers—constitute the main objects of data literacy education. The *14th Five-Year Plan for National Informatization* issued by the Central Cyberspace Affairs Commission on December 27, 2021, includes "Citizens' Digital Literacy and Skills Enhancement Action" as one of ten priority areas, providing direction for high-quality development of data literacy education for data librarians, researchers, and teachers.

Efficient Research Data Management as the Primary Objective. For individuals, data literacy education aims to improve data mining, analysis, and application skills. From a national strategic perspective, the main objective is to enable data elements to generate synergistic and innovative effects throughout their production, flow, and development according to specific scientific logic. Therefore, for society as a whole, achieving efficient research data management is an important guarantee for digital transformation across industries and the primary goal of improving citizens' data literacy.

Data Literacy Education Evaluation to Demonstrate Effectiveness. Like information literacy education evaluation in the previous era, data liter-

acy education evaluation remains crucial in the current data-centric digital and intelligent age, as it relates to the quality cultivation of data industry talent. In the digital humanities context, evaluation also determines educational effectiveness across disciplines. However, with developments in big data, AI, and related technologies, evaluation methods differ from traditional information literacy assessment. Current and future evaluations must fully mine all-element data regarding subjects, objects, and interaction patterns, applying digital and intelligent scientific evaluation methods for real-time tracking and scientific feedback to ensure high-quality data literacy education.

Digital-Intelligence Era as the Environment. Under next-generation information technologies such as big data, IoT, cloud computing, and AI, all industries face higher-level digital and intelligent transformation, making data elements core strategic resources in future production. Data mining and development lose value when detached from their associated digital-intelligence environment. Data literacy cultivation requires all participants to grasp the full lifecycle of data production, cleaning, storage, updating, collaboration, and obsolescence. Therefore, both subjects and objects of data literacy education must base their cultivation efforts on this specific digital-intelligence environment.

In summary, libraries and LIS disciplines serve as the main arena and subjects of data literacy education, promoting improvement in data librarians, researchers, and teachers. Enhanced data literacy among researchers contributes to research data management, while evaluation of subjects and objects demonstrates education effectiveness, creating a feedback loop. The digital-intelligence environment drives research data management requirements and promotes data literacy education. Thus, various data literacy research themes are interdependent and mutually reinforcing. The relationships among these elements are illustrated in [Figure 6: see original paper].

According to the strategic coordinate diagram (see [Figure 5: see original paper]), "Data Librarian Data Literacy" (Theme 2) has the highest centrality (0.368), followed by "Library Data Literacy Education"(Theme 5) (0.243). Therefore, these two themes will become future research trends. As China' s data literacy education shifts from traditional subject and information services to data services, a new generation of librarians (data librarians) will emerge, with research focusing on service systems, job responsibilities, and data skills.

5. Conclusion

Under the "digital-intelligence" trend, accelerated innovation in big data, AI, blockchain, and cloud computing is driving digital economy development. As a new production factor, data injects new momentum into the digital economy and profoundly impacts social development. Data literacy, as the cornerstone of digital economic and social development, helps people quickly adapt to new business forms and models, becoming an essential competency for everyone and a focal point of academic discussion.

The study reveals that data literacy research content is becoming more diversified, with education objects, methods, and content showing diverse development patterns. Analysis of education objects shows that data literacy education has expanded beyond traditional librarians or information analysts to the entire population, including teachers, researchers, and librarians. Regarding education methods, data literacy education is developing through multiple channels, with online-offline integration emerging in the post-pandemic era and cross-disciplinary, cross-regional cooperation patterns gradually forming. In terms of education content, research has become richer, focusing not only on data retrieval, acquisition, and organization skills but also on data ethics, data thinking, data processing, data mining, data sharing, and data preservation. Moreover, content is increasingly aligned with actual production and life needs.

Overall, data literacy research must advance with the times, and data literacy education research must meet the requirements of era development. While improving citizens' data literacy, we must continue to refine evaluation systems and promote data literacy research.

References

[1] STEPHENSON E, CARAVELLO P S. Incorporating data literacy into undergraduate information literacy programs in the social sciences: a pilot project[J]. Reference services review, 2007, 35(4): 525-540.

[2] HUANG R H, LI B Y. Data literacy education: an extension of information literacy education in the big data era[J]. Library and information science knowledge, 2016(1): 21-29.

[3] MENG X B, QIAN P. International experience and implications for university social science data management: taking UKDA and ICPSR as examples[J]. Information and documentation services, 2013(2): 77-80.

[4] CALLON M, COURTIAL J P, TURNER W A, et al. From translations to problematic networks: an introduction to co-word analysis[J]. Social science information, 1983, 22(2): 191-235.

[5] COBO M J, LÓPEZ-HERRERA A G, HERRERA-VIEDMA E, et al. An approach for detecting, quantifying, and visualizing the evolution of a research field: a practical application to the fuzzy sets theory field[J]. Journal of informetrics, 2011, 5(1): 146-166.

[6] BAILEY K D. Numerical taxonomy and cluster analysis[J]. Typologies and taxonomies, 1994, 34: 35-65.

[7] ECK N J V, WALTMAN L. How to normalize cooccurrence data? an analysis of some well-known similarity measures[J]. Journal of the American society for information science and technology, 2009, 60(8): 1635-1651.

[8] LAW J, BAUIN S, COURTIAL J P, et al. Policy and the mapping of scientific change: a co-word analysis of research into environmental acidification[J].

Scientometrics, 1988, 14(3-4): 251-264.

[9] CALLON M, COURTIAL J P, LAVILLE F. Co-word analysis as a tool for describing the network of interactions between basic and technological research: the case of polymer chemsitry[J]. Scientometrics, 1991, 22(1): 155-205.

[10] LEE B, JEONG Y I. Mapping Korea' s national R&D domain of robot technology by using the co-word analysis[J]. Scientometrics, 2008, 77(1): 3-19.

[11] GIANNAKOS M, PAPAMITSIOU Z, MARKOPOULOS P, et al. Mapping child–computer interaction research through co-word analysis[J/OL]. International journal of child-computer interaction, 2020, 23: 100165 [2021-11-01]. https://www.sciencedirect.com/science/article/pii/S2212868920300015.

[12] WANG K, GAO J P, PAN Y T, et al. Research on multi-state research topic identification and evolution path methods[J]. Library and information service, 2021, 65(11): 39-49.

[13] LEI C R, CHEN M. Comparative study on data literacy education in domestic and foreign university libraries[J]. Library, 2021(4): 47-51.

[14] LIANG Y, ZHENG Y P. Influencing factors and coping strategies for doctoral students' data literacy in universities[J]. Information studies: theory & application, 2021, 44(4): 146-152, 137.

[15] HUI G J, ZENG L. Data literacy in the intelligent era: model construction, indicator system, and training paths—based on comparative analysis of domestic and international models[J]. Journal of distance education, 2021, 39(4): 52-61.

[16] GU L P, ZHANG X Y. Practical analysis of data librarians in the open science environment[J]. Library and information science knowledge, 2020(2): 60-74, 112.

[17] ZHANG L, SHENG X J. Investigation and comparative study on data librarian training practices at home and abroad[J]. New century library, 2020(2): 31-35, 47.

[18] LI M. Research data service innovation and new roles of data librarians in university libraries: a case study of the University of Edinburgh[J]. Library and information, 2019(3): 122-130.

[19] WANG N, WANG Z Y. Research on hierarchical training models for university librarians' data skills driven by big data[J]. University library work, 2018, 38(4): 10-17, 47.

[20] CHEN Y Y, KE P. Research on the development of data librarians' professional skills in university libraries[J]. Information and documentation services, 2018(2): 97-102.

[21] XU X, ZHANG Y. The transformation of librarians' roles in the data era: the rise of data librarians[J]. Library and information service, 2021, 65(7): 60-66.

[22] LI W W, ZHOU P. Research on scientific literacy education based on the research lifecycle[J]. Modern information, 2017, 37(1): 156-159.

[23] LASSWELL H D. The structure and function of communication in society[J]. The communication of ideas, 1948, 37(1): 136-139.

[24] ZHU J. Analysis of public library data literacy education systems[J]. University library work, 2020, 40(5): 80-84.

[25] ZHANG C L, WANG C X, LI J T. Comparative study on data literacy education in Chinese and American universities in the big data era[J]. Information studies: theory & application, 2019, 42(8): 52-57.

[26] PAN X, CHEN Y. Analysis of evaluation index systems for data literacy education in Chinese universities[J]. New century library, 2018(7): 31-34.

[27] WU A Z, WANG S. Design of data literacy education systems in university libraries: a case study of Peking University Library[J]. Journal of academic libraries, 2020, 38(6): 96-103.

[28] ZHANG W L, LIU J Y. Preliminary exploration of a framework for data literacy education systems in Chinese university libraries[J]. University library work, 2017, 37(4): 80-84.

[29] XIAO X M, NI P. Investigation and comparative analysis of data literacy education in Chinese and American LIS education[J]. Library and information, 2018(1): 20-27.

[30] LI Q, REN Y S. Research and practice status of foreign teachers' data literacy education[J]. Open education research, 2016, 22(6): 65-73.

[31] LI Q, REN Y S. Teacher data literacy competency model and development strategies[J]. e-Education research, 2016, 37(5): 120-128.

[32] LI X, YANG X M. Design and practice of training courses for primary and secondary school teachers' data literacy[J]. China educational technology, 2020(5): 111-119, 134.

[33] LIN X Q, YANG X M, LI Y F. Construction of an evaluation index system for primary and secondary school teachers' data literacy[J]. Chinese journal of distance education, 2020(2): 49-56, 75, 77.

[34] LIN X Q, YANG X M, LI X. Development paths and training strategies for primary and secondary school teachers' data literacy[J]. Modern educational technology, 2020, 30(1): 59-65.

[35] XU Y F, PENG X, CAO Y, et al. The connotation, function, and development of teachers' digital intelligence literacy from the perspective of human-computer collaboration[J]. Journal of distance education, 2020, 38(6): 13-21.

[36] SI L, YAO R F. Curriculum design and characteristic analysis of data literacy for LIS graduate students: a survey of iSchool alliance institutions[J]. Library and information, 2018(1): 28-36, 101.

[37] ZHOU L X, ZHOU L, AI W H. Analysis of graduate data literacy education in LIS programs under the big data background[J]. Library and information service, 2019, 63(19): 34-41.

Author Contributions: Li Jiaojiao conducted data processing and analysis and wrote and revised the manuscript; Yang Zhihe wrote and revised the manuscript.

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