Exploring the Roles and Responsibilities of Librarians in Data Visualisation:
A Road to Open Data Service

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ABSTRACT
Data visualization, as a library service, can help users present complex data in a more understandable visual form and promote data sharing and reuse, which is in line with the core principle of open science - the concept of open data. This study aims to explore the role and corresponding responsibilities of Chinese academic librarians in data visualization to promote the development of open data services. The study purposefully invited 12 librarians with experience in providing data visualization services from 10 top-tier universities in China, collected data through semi-structured interviews, and analyzed the data using NVivo software to gain insights into the roles and responsibilities of librarians in the process of data visualization services. The findings suggest that the role of librarians in the context of increasingly embedded DV implementations in libraries is becoming more diverse, including but not limited to Steward, Trainer, Collaborator, and Advocate. Meanwhile, librarians are taking on more responsibilities related to data visualization, such as enriching open data platforms, guiding users on data features and visual services, helping users develop data visualization skills, and promoting data-driven innovation, etc. This study provides valuable insights into the evolving role of librarians in the age of open data and offers practical guidance for librarians who wish to use and implement data visualization services to support such initiatives. Meanwhile, the continued promotion of data visualization in the open data environment will also help researchers better communicate their findings and ideas and make their work understandable to a wider audience, which is an invaluable way to promote transparency and collaboration in scientific research.

Keywords: Data Visualisation; Open Data Service; Academic librarian; Role and Responsibility

INTRODUCTION

The rise of open data has led to an exponential growth of publicly available and accessible datasets, while the effective interpretation and integration of these heterogeneous, vast, and distributed datasets poses new challenges for research and decision-making processes. Data Visualisation (DV), employing visual elements such as charts, graphs, and maps, has evolved into a pivotal tool for facilitating open data integration by intuitively presenting intricate underlying data (Carvalho et al. 2015). (Carvalho et al. 2015). In recent years, as academic libraries have progressively engaged in open science and open data initiatives, they have taken on the responsibility of acquiring, managing, and storing research data. They have emerged as fundamental hubs for research data services and have evolved into vital proponents of research data visualization (Tenopir et al. 2013). Within this context, data visualization aims to facilitate users' enhanced understanding of data, the discovery of patterns and insights within datasets, and the extraction of deeper insights. This pursuit serves to advance research, facilitate decision-making, and foster innovation. It signifies a novel approach that encourages broader access to and utilization of data within the researcher and academic community.

Increasing evidence suggests that Data Visualisation Services (DVS) as a library practice is an inevitable trend (Ogier and Stamper 2018). According to the Association of College and Research Libraries (ACRL) publication "Top Trends in Academic Libraries 2020", most libraries that offer advanced research data services have already provided support and training in DV and related areas (ACRL Research Planning and Review Committee 2020). Given the demands and transformations in the development of DVS, librarians, as the primary providers of library services, have unique position opportunities and professional advantages to contribute to the exploration of DV in libraries and play a crucial role in promoting access to open data services. The library field in the United States has also investigated the various factors influencing library services, with results showing that librarians' influence exceeds that of resources and the environment by 75% (Chen and Ke 2018). Clearly, researching the role positioning and responsibilities undertaken by librarians in specific service contexts is of utmost importance and should not be overlooked.

In light of the significant influence of technological advancements, evolving tasks, changing user demands, and the transformation of library services, the roles and responsibilities of librarians are undergoing dynamic shifts and expansions, surpassing the traditional realm of information services, resulting in more diverse role descriptions (Luo 2018). However, despite the growing discourse on data visualization services in academic libraries, there remains a dearth of analysis regarding the role positioning, and responsibilities of librarians in the context of providing such services, which will not be conducive to the development of a positive library service model in the new technological change environment.

Therefore, this paper intends to explore the multidimensional role of librarians in data visualization and the potential responsibilities they may face by capturing the real-world perceptions and insights of actual operational participants. By facilitating an open discussion, it is hoped that this research will inspire librarians and information professionals to embrace

data visualization as a strategic tool for their open data services, recognizing its potential to drive innovation and empower development.

LITERATURE REVIEW

Research has shown that the human brain is more efficient in processing visual images than numerical information. Therefore, it is possible to transform complex data into visually clear representations through visualization techniques, enabling users to obtain valuable information with greater speed and sharper insights (Murphy 2013; Finch and Flenner 2016). With the rise of big data and open data, data visualization has gradually emerged as a crucial tool for enhancing data comprehension, gaining insights into emerging trends, and driving data-driven decision-making. As a result, it has garnered significant attention within the library industry (Wen et al. 2020).

Numerous studies have consistently indicated that in recent years, data visualization has increasingly been integrated into libraries, making it a new exploratory trend in library services (Eaton 2017; Zakaria 2021). Scholars have discussed the significance of data visualization services, noting that it extends research data management provided by libraries (Stamper 2019) and represents a powerful transformation from information services to knowledge services (Chu and Zhao 2019). It is believed that data visualization can also facilitate transparency, collaboration, and accessibility in the research process. By making data and research findings easier to access and understand, researchers can encourage others to build upon their work and foster an open and collaborative culture in scientific research (Suwanworaboon et al. 2020). Similarly, researchers from different countries and regions have conducted surveys on data visualization from a supply perspective, finding that its services encompass various aspects, including information support, resource services, Consultancy analysis, and literacy education (LaPolla et al. 2020; Zakaria 2021; Su et al. 2022). This reaffirms the increasing importance and prevalence of data visualization in library services, particularly in the context of current demands for data openness, which warrants further exploration.

The study of librarians' roles has been a prominent topic in library science. Whether it pertains to improving service models or exploring library development, numerous researchers have emphasized the indispensable role of librarians as service leaders in the evolution of library services (Shupe 2015; Huo and Lu 2020). As the social, technological, and demand landscape within libraries continues to evolve, Luo (2018) conducted an analysis of bibliographic information from English-language journals and found that the responsibilities and roles of librarians have undergone transformational changes. Librarian roles have shifted from information assistants to trends of trainers and technical support experts, and that the new, highly professional role of librarians is also being given a more diversified set of responsibilities. Moreover, based on case analyses of data management services, Choudhury (2008) identified novel roles and relationships between libraries and academia, with a specific emphasis on the collaborative relationship between librarians and researchers in the realm of research data. According to the research by Thomas and Urban (2018), data librarians can

assume various roles in library services, including data manager, data engineer, data steward, data curator, and data scientist, among others. Chinese researcher Gu (2020) further emphasized the significance of categorizing the professional roles of data-related librarians based on the level of data resource handling in an open science environment, and this perspective is derived from a summary of previous studies. Notably, the influential role of librarians in enhancing users' literacy and promoting civic engagement has been acknowledged. Researchers propose that roles such as resource integrator, partner, and facilitator can significantly shape the direction of librarians' work (Kine and Davidsone 2022).

As data visualization technology becomes deeply embedded in libraries, studies in this field have attempted to analyze how roles such as "Data visualization Experts" established at Ohio State University, "Embedded Librarians," and "Data and visualization Science Consultants" provided by Duke University Library assist libraries in offering users professional and personalized services (Wen et al. 2020; Zakaria 2021). The emergence and evolution of these specialized titles provide librarians with a more defined dimension to their roles. However, they also bring about heightened responsibilities, necessitating continuous updates and improvements based on real-world practices.

RESEARCH DESIGN

The aim of this study is to examine the roles and responsibilities of librarians in data visualization from a service perspective, thereby analyzing their potential as catalysts for open data services. To achieve this research objective, the following research questions are addressed in this research:

(a) What roles do librarians play in the data visualization services provided by the library within the context of open data?
(b) What specific responsibilities should librarians assume in the data visualization services, corresponding to their professional role?

This is an exploratory study that collects qualitative data through semi-structured interviews. One major advantage of selecting a semi-structured interview approach is that it provides interviewees with considerable freedom to deviate from and expand upon the research topic, allowing for a more flexible exploration based on participants' responses (Polit and Beck 2010; Bryman and Bell 2015). For this study, a web survey and environmental scan were conducted on the official websites of academic libraries affiliated with 42 top-tier universities announced by the Chinese Ministry of Education (MOE). Ultimately, 16 academic libraries (ALs) with more extensive experience in providing data visualization services were selected as the potential sample for this study (The flow is shown in Fig. 1). Academic librarians with experience in providing data visualization services or possessing academic backgrounds in data visualization were purposely sampled as they were believed to provide more insightful perspectives on data services and visualization support, thus serving as better research participants for generating high-quality responses related to the study.

The selection of the sample primarily included the following inclusion criteria:
(a) They have shown interest in the study and are willing to be interviewed.
(b) They are librarians from the sampled academic libraries.
(c) They have a certain level of work experience or academic knowledge related to data visualization.
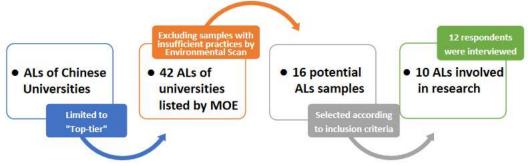

Figure 1: The Flow Diagram of Sample Selection

Ultimately, 12 librarians from 10 university academic libraries who met the above criteria were invited through email invitations and recommendations and were interviewed between November 2022 and March 2023. The demographic attributes of the participants are listed in Table 1. To ensure the anonymity of the respondents, each Academic Librarian participant was given a serial number from AL1-AL12 and the 10 universities to which they affiliated were coded as A-J. Due to the pandemic management policies in China, interviews were conducted through online meetings and face-to-face interviews, with each interview recorded using both recording software and digital recorders, ensuring clarity and accuracy in data collection.

Table 1: Demographic Attributes of the Participants

Code	DVS experience	Code	DVS experience
AL1A	Consulting Report	AL7F	Digital Resource Construction
AL2B	DV Software Lecture	AL8F	Data Analysis & DV Seminar
AL3C	Project Planning & coordination	AL9G	Annual Reading Report
AL4D	Core curriculum instruction	AL10H	Information Consultation Services
AL5D	Open Resource Platform	AL11I	Literacy Competitions & Training
AL6E	DV Service Platform & Project	AL12J	Literacy Education Support

RESULTS

With the transformation of the library's technological environment and service functions, the professional identity of librarians has undergone dynamic changes, and the responsibilities they face are continuously evolving (Luo 2018). In the context of open data, the emergence of more data visualization-related service scenarios is disrupting the role positioning of

librarians, shifting from a supportive role to a more dominant position. Leckie et al. (2016) pointed out that, apart from certain specialized roles, professionals often play many different roles throughout the day, including managerial, advisory, and even research-related roles. This study describes the job roles of librarians in providing Data visualization Services (DVS) to analyze the tasks they need to undertake based on their roles. It is a repositioning of the responsibilities and functions of librarians and provides support for the subsequent capabilities of librarians in Data visualization Literacy. By understanding and analyzing the perspectives of participants, the preliminary findings reveal that librarians in academic libraries in Chinese universities play four main roles in data visualization services: Steward, collaborator, trainer, and advocate (see Table 1). The specific responsibilities they may need to assume are as follows:

Table 2: Librarians' Roles and Responsibilities in providing DVS

Role	Responsibility
Steward	Coordinate relevant resources and enrich the open data platform
	Establishing effective bidirectional interaction with stakeholders
	Improving management efficiency and service quality
Collaborator	Building collaborative partnerships throughout the research lifecycle
	Promote knowledge integration across disciplines and stakeholder
	Assist users in capturing data features and visual representations
Trainer	Provide a diverse range of training and educational activities
	Developing high-quality open educational resources for DV
Advocate	Advocating actively for the significant value of DV & open data
	Promote innovation in data-driven decision-making and services

Steward

The role of a steward has traditionally been defined as "the person who directs, supervises, or manages something", while more proactive accountability of "prudent and responsible administration" has elicited development in recent years (Constantinescu 2018; Fagan et al. 2020). From the perspective of providing data visualization services, stewardship is the fundamental mission of librarians. It should be based on David Siewert's concept of "sustained attention" and should involve stewardship in multiple dimensions such as planning, guiding, and managing applications. This role maximizes the utility of library resources and services, providing support for the transformation of the open science environment and the exploration of open data services. Analysis of the interview data revealed three responsibilities described below.

As stewards, librarians have the crucial task of providing appropriate leadership in their work, macro-organizing, and managing various resources such as data and information. As more and more libraries are building and improving open data platforms to assist researchers in storing, sharing, and reusing datasets, providing corresponding statistical data and visualizations will be one of the important directions in the future transformation of library services.

> In terms of our current library development direction, if he wants to do this data visualization, perhaps our focus might be on the construction of this discipline and academic support. This is the focus of future development... This data visualization is definitely based on our resources. At least it should touch all the data in the entire library, including resources, services, and most importantly, various types of user data. All data should be clearly mapped and then connected to the system. Then, his visualization work will be carried out quickly and effectively. (AL3C)

Furthermore, data visualization as a library service also implies its orientation towards different stakeholder groups and diverse user needs. It is necessary for librarians to enhance their communication and application skills, establish direct and two-way interactive relationships with stakeholders through proactive development, feedback-oriented improvement, and continuous refinement. This enables correct service positioning and navigation, resulting in mutual benefits.

> Actually, we have always adhered to a user-centered approach... In recent years, there has been an increasing demand from library users for intelligence analysis and data services... I believe we must fulfill this intermediary role, integrating users' research data and information resources more closely through our services. (AL6E)

Pursuing higher levels of management efficiency and optimizing the operational effectiveness of library services should be a constant work guideline for librarians. As the suppliers of library services, librarians can contribute to the development and sustainability of the library by organizing and managing resources, human resources, time, and other aspects through rational workflow planning, optimized task allocation, and the utilization of visualization tools.

> It can be said that we are currently in an era of information explosion with abundant resources and human resources in the library... How to efficiently allocate and coordinate these resources, how to help users efficiently obtain what they need, or how we can help them save time, these are what we need to do... (AL9G)

Collaborator

Collaborators are individuals who actively and reliably utilize their professional abilities to assist others in achieving plans, organizing, guiding, evaluating, and other work tasks with higher quality and efficiency (Nolen et al. 2021). Various studies have emphasized the benefits of collaboration between research teams and librarians, leading to better research outcomes and easier problem-solving (Reynolds et al. 2013; McBurney et al. 2020).

As collaborators in the field of data visualization services, the primary responsibility of librarians is to establish close partnerships with researchers, data providers, social organizations, and others throughout the research lifecycle. They collaborate with various stakeholders to facilitate data acquisition, management, and sharing. Librarians actively engage in collaborative and co-creation projects, providing expertise in data management,

analysis, and visualization. They assist partners in data processing and visual presentation to achieve shared research goals.

> I believe this should be a role of a research collaborator, offering assistance in research to students and faculty in areas they are not familiar with, and providing professional collaboration. (AL2B)
> Just like many foreign universities have similar specialized librarian positions to connect disciplines, departments, and researchers, playing a bridging role in scientific research. (AL7F)

Moreover, librarians' subject-specific services can serve as effective liaisons for disciplines. With their professional understanding of research trends and information architecture in specific disciplines, they possess the expertise to help address interdisciplinary research by providing researchers with solutions and seeking answers to questions (Noren et al. 2021). This demonstrates their role in serving the discipline's development. Librarians engage in interdisciplinary collaboration, integrating knowledge and expertise from different fields. They collaborate with researchers from various disciplines, facilitating the application of data and cross-disciplinary research. By providing targeted support and collaboration through data processing and visualization, they foster cooperation and innovation across different disciplines.

> The library is now far beyond the scope of the original purely documentary resource service...like our university, maybe the important aspect of the library is not only to serve the teachers and students but also to focus on the development of multidisciplinary integration and first-class construction. (AL1A)

In the context of data visualization services, librarians collaborate by assisting partners in capturing data features and facilitating visual representation. They provide guidance on data visualization tools and techniques, offer cutting-edge intelligence analysis reports in specific disciplines, and assist in data acquisition and knowledge resource integration. These efforts help collaborators extract data features, accomplish visual transformations, and drive data-driven decision-making.

> In fact, we play a role as a medium, relying on the information resources within our library and the library platform, providing our users with these large-scale basic data based on scientific research literature, factual data, patent data, or patent indicators...thus helping our users, whether they are researchers, academic leaders, or external institutions, to obtain more accurate and intuitive data features and information. (AL10H)

Trainer

A trainer refers to someone who helps stakeholders improve their knowledge and skills and fulfill their motivational needs by providing teaching or practical opportunities (Manuell and Adams 2016). With the ongoing reforms in higher education, universities are placing more emphasis on cultivating student competence (Kirker 2022). University libraries, not only serving as traditional information resource institutions but also carrying important training

responsibilities, are instrumental in meeting the demands of higher education. By assuming the role of trainers, librarians can assist users in acquiring data visualization literacy necessary for learning, research, or future work, enhancing their data analysis and decision-making abilities, and thus better utilizing open data while promoting the development and quality of library services.

On the one hand, the starting point for cultivating users' data visualization skills lies in providing training and educational activities. Librarians can design training courses suitable for different levels and content based on users' needs and proficiency. Through well-organized skill enhancement programs, workshops, customized embedded courses, and competitions, librarians can popularize users' awareness of data visualization, impart basic knowledge and skills in data visualization, and actively promote the cultivation of data visualization literacy, thus playing the role of literacy trainers.

> From a curriculum point of view, it is clearer that we play more of a role as a literacy educator. However, if we think about it from a competitive point of view, I think it is more diversified, not through one event that can play an educational role, but through a systematic chain and a process... We can fully integrate multiple educational models such as courses and competitions with each other to get students actively involved. (AL11I)
> For universities, the library is essentially an educational and research environment, and we librarians are constantly exploring better ways to enhance user literacy in many ways, from awareness-raising to basic pedagogy to advanced seminars. (AL12J)

On the other hand, in the context of open science, the development of open educational resources will undoubtedly be a key direction for the future cultivation of data visualization. Librarians can develop and provide various educational resources such as instructional manuals, online tutorials, video lectures, etc., to support users' learning and independent exploration. These resources can include fundamental knowledge of data visualization, operating guidelines, sample codes, and datasets, providing users with reference materials and practical materials for learning. At the same time, by organizing learning groups, online communities, and other means, users are encouraged to share experiences, learn from each other, and collaborate, thereby promoting the dissemination and sharing of data visualization knowledge.

> We are currently working on a cloud-based teaching and research project, which aims to provide more convenient teaching and research opportunities and diverse shared resources for members through the collaboration of multiple university libraries and online communication and discussions. We are also continuously inviting more libraries to participate. (AL4D)

Advocate
An advocate is someone who understands the value and importance of what they advocate for and consciously pleads for a cause, voluntarily conveying or presenting ideas. Librarians are among the important advocates in the development of library services. When librarians

advocate for the services they provide, they are essentially advocating for the values of the profession (Hicks 2016).

In the trend of open data and sharing, as advocates, librarians should be committed to upholding the positive value of data visualization. They encourage the visual representation of data through data visualization by advocating for open data policies and urging governments, organizations, and research institutions to provide data resources in an open manner to the public and research communities. Librarians actively participate in data visualization initiatives and raise awareness and understanding of open data and its application through popularization, promotion, and dissemination activities.

> The important task requires that we play an active role by ourselves as librarians...assist the school's discipline construction, talent introduction, decision-making consultation, and help colleges and researchers to study topics and facilitate the smooth implementation of projects. (AL5D)

In the context of data visualization services in libraries, promoting data-driven innovation is equally important. This means that librarians should actively utilize data visualization techniques and methods to stimulate and support innovative thinking and drive and guide decision-making and problem-solving processes based on the potential of data. By applying data visualization to specific projects or domains, librarians can uncover new insights, develop new service models, and provide more innovative and targeted services, thereby enhancing the value and impact of the library.

> In a data-driven context, there is a pressing need to change our understanding of the functions, nature, and roles of libraries. Whether it is data services or visualization services, the main purpose is to enhance the soft and hard capabilities of our libraries, requiring our librarians to use their own initiative to help optimize it more effectively. (AL8F)

The findings generally affirm the irreplaceable role of librarians as service providers and emphasize the important role of librarians in data visualization and the description of targeted responsibilities. It is evident that librarians have multiple roles depending on their different service requirements, with each role involving intersecting and complementary tasks, including Steward, Trainer, Collaborator, and Advocate dimensions. Furthermore, it is evident that the participants generally hold an optimistic attitude towards the development path of data visualization provided by libraries. They believe that data visualization, as a library service, will bring new opportunities to libraries in the data-driven era through continuous optimization of service models and exploration of service depth.

CONCLUSION

Data visualization has become a powerful tool in the era of open data, enabling organizations and individuals to effectively understand and communicate complex information. Library

Data visualization Services (DVS) can assist users in presenting complex data in a visual format, creating clear and meaningful visual representations. These visualizations can be used to facilitate scientific communication, showcase research findings, and attract more scientists to a specific field of study, thereby promoting collaboration and data sharing. The findings of this study indicate that under the influence of multiple factors, some traditional roles of librarians are gradually being integrated or replaced by technology. The role description of librarians has become more diverse, with overlapping and multiple role orientations. The roles of library administrators, trainers, collaborators, and advocates have their own background characteristics and task requirements. As they integrate and grow together, higher demands are placed on the corresponding data visualization skills of librarians.

While emphasizing the positioning and differentiation of librarians' roles and responsibilities, we should also recognize that driving library practice and achieving excellence in the library profession necessitates librarians to continuously enhance their knowledge and skills, optimize their professional attributes and conduct, encourage the ongoing professional development of colleagues, and foster the ambitions of potential industry members. By bridging the gap between data creators and data consumers, librarians can effectively interpret and utilize data, thereby facilitating the transformation and upgrading of library knowledge services and enhancing competitiveness in open data services.

The insights gained from this study will better position librarians for their new roles under data visualization services, provide a description of the job responsibilities to which they may be exposed, as well as suggest new ideas for optimizing and upgrading librarianship under the requirements of open data services. Nevertheless, it should be noted that the scope of this study only attempted to explore the views and perceptions of academic librarians in selected universities in China, and the sample size was relatively small, which may limit the general applicability of the findings, and we expect to be able to consider in-depth service scenarios and invite a wider group of respondents to participate in future studies in order to gain a more comprehensive understanding of our research questions.

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