

ACADEMIC INFORMATION ACCESS BARRIERS AND SUPPORT STRATEGIES FOR COLLEGE STUDENTS WITH HEARING IMPAIRMENTS

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Abstract: With the popularization of higher education and the advancement of educational equity, hearing-impaired college students face multiple unique challenges in the process of accessing academic information. These challenges not only affect their learning efficiency but may also hinder their academic development and personal achievements. Based on the framework of information ecology theory, this study systematically identifies the core obstacles hearing-impaired college students encounter throughout the entire academic information acquisition process, including four dimensions: information communication, technological environment, information resources, and support services. By drawing on exemplary cases from domestic and international university libraries, this paper constructs a multi-stakeholder collaborative support strategy system from the four elements of information ecology: people, technology, information, and environment. The system advocates closely integrating hearing-impaired students, teachers, technology developers, and information service institutions, establishing effective communication mechanisms, and optimizing access channels to information resources for hearing-impaired college students, aiming to provide theoretical reference and practical pathways for service optimization in university libraries and related departments.

Keywords: Hearing-impaired college students; Academic information acquisition; Information barriers; Information ecology theory

1 INTRODUCTION

1.1 Research Background and Significance

Under the background of the popularization of higher education and the deepening of educational equity in China, hearing-impaired college students face unique challenges in academic information acquisition, which affects their learning efficiency and academic development. This requires researchers to pay attention not only to the equality of physical access but also to the equality of information acquisition and knowledge dissemination. For example, they encounter systematic and difficult challenges in many aspects such as attending lectures, participating in discussions, and receiving guidance. They cannot proceed as smoothly as other students, which further influences their learning outcomes and academic development. Therefore, they naturally need more support in obtaining academic information so that they can fully participate in normal learning and research activities.

The theoretical significance of this study is unique in the following ways. First, rather than simply listing barriers or strategies, it adopts the four elements of information ecology theory—people, technology, information, and environment—as a systematic analytical framework throughout the whole process of barrier diagnosis, case interpretation, and strategy construction. This distinguishes it from existing studies that mostly focus on micro-level behavioral descriptions or meso-level service improvements. Through this framework, the study aims to reveal the nature of systemic imbalance in the interactions among barriers, and accordingly build an integrated supportive ecosystem where all elements interact positively and multiple stakeholders collaborate, instead of providing fragmented suggestions. This constitutes the core theoretical contribution and the main line of analytical logic of this study. Second, by combining perspectives from multiple disciplines such as information science, education, and psychology, this study promotes interdisciplinary research cooperation. Such a comprehensive approach helps to establish more systematic support strategies that go beyond information acquisition to include personal development, academic adaptation, and other aspects, thereby forming a diversified theoretical system.

The practical significance is also notable. This study aims to provide a complete solution from problem diagnosis to system construction for improving the effectiveness of hearing-impaired college students' academic information acquisition ability. First, at the level of service optimization: through systematic analysis of barriers, it provides accurate and actionable suggestions for service improvement and collaborative work for university libraries, disability student support centers, and academic affairs departments, directly enhancing the quality and efficiency of accessible support services. Second, at the level of student empowerment: through the constructed support strategy system, it aims to directly help hearing-impaired college students overcome specific difficulties in information acquisition, thereby effectively improving their information literacy and academic adaptability, and promoting their academic success and social integration. Third, at the level of system advancement: the integrated strategic framework proposed by the study aims to push universities to adopt more inclusive and systematic measures in policy and practice, shifting from “special

care” to “ecological construction,” and providing a reference path for substantially advancing equity in higher education.

1.2 Review of Current Research

With the development of inclusive education, “academic information acquisition of hearing-impaired college students” has become an interdisciplinary topic between library and information science and special education. Discussion on this issue has deepened along with the advancement of inclusive education.

Based on existing literature, scholars’ research focuses mainly on the following aspects. First, in terms of information behavior and characteristics, Zhou Caiying et al., Fan Rao, Liu Chunping, and Tong Lei found that hearing-impaired college students show a strong visual orientation [1-4], mainly relying on text and images to obtain information. Their information needs are practicality-oriented, but they have difficulties in search strategies, evaluation, and expression. Their information awareness is relatively weak, and they do not make full use of electronic resources. Second, regarding barriers to using libraries, Yuan Shuo et al., Tong Lei, Zhou Caiying et al., and Liu Chunping found that regular information retrieval courses and self-service models fail to fully consider their reception characteristics [1,3-5]. The “information islands” formed by massive databases and instructional videos lacking subtitles hinder resource utilization. In addition, insufficient accessibility facilities and services (such as lack of sign language services and non-accessible website design) further limit the effectiveness of use. Third, concerning support service strategies of university libraries, to address the above barriers, Yuan Shuo et al., Tong Lei, and Liu Chunping proposed directions such as conducting personalized training [3-5], organizing subtitle groups, designing accessible systems, improving librarians’ awareness, carrying out information literacy education, and creating a humanized service environment. Furthermore, from a broader perspective of information technology and inclusive education support systems, scholars Fan Rao and Wu Fang emphasized the importance of building an accessible information campus environment [2,6], developing visual course resource platforms, and constructing accessible smart classrooms through technological empowerment.

Overall, existing studies have clearly revealed the unique information behavior characteristics of hearing-impaired college students and preliminarily discussed the main barriers they face when using libraries and academic resources, as well as corresponding service countermeasures. However, current research mostly focuses on micro-level descriptions of information behavior and meso-level improvements of library services, lacking a systematic barrier analysis of the entire process of “academic information acquisition” (from need generation, searching, understanding and evaluation to academic application). In terms of support strategies, most suggestions are fragmented and fail to effectively construct a collaborative support ecosystem that integrates multiple subjects such as individual students, libraries, departments, technical units, and even student communities. Moreover, existing studies pay insufficient attention to the barriers hearing-impaired college students encounter in acquiring “tacit knowledge” through informal communication such as academic social interaction and lecture participation.

Therefore, to fill these gaps, this study explicitly introduces “information ecology theory” as a systematic analytical framework. Different from existing studies, this study aims to use the four elements of the theory—people, technology, information, and environment—to conduct a whole-process and integrated barrier diagnosis of hearing-impaired college students’ academic information acquisition, revealing the interrelationships among barriers. Based on this framework, it strives to construct a multi-stakeholder collaborative and element-coordinated support strategy system, rather than providing scattered suggestions. This constitutes the core idea and theoretical exploration of this study in response to the shortcomings of existing research.

1.3 Research Content and Methods

1.3.1 Research content

First, this study will focus on analyzing the systematic barriers faced by hearing-impaired college students throughout the entire process of academic information acquisition, and accordingly construct an integrated support strategy system. The specific research content is as follows: Whole-process barrier analysis: This paper breaks through the limitation of existing studies that concentrate on the single stage of “information retrieval.” It regards academic information acquisition as a dynamic and continuous process, namely, starting from the generation of information needs, moving to information retrieval and acquisition, then to information understanding and absorption, and finally to information utilization. Each stage will be diagnosed in depth and detail.

(1) Stage of information need generation: This part focuses on analyzing the problems of vague, unclear, and delayed academic information needs caused by difficulties in listening to lectures. For example, teachers speak too fast, and professional terms are difficult to accurately capture through lip reading.

(2) Stage of information retrieval and acquisition: This part systematically examines technological and environmental barriers, including compatibility issues between mainstream academic databases and library retrieval systems (such as CNKI, Web of Science) and assistive technologies like screen readers and magnification software; non-accessible interactive design of information retrieval interfaces (e.g., lack of keyboard navigation support, difficulty in recognizing for visually impaired users); and the absence of guiding systems in the physical library space.

(3) Stage of information understanding and utilization: This part deeply explores cognitive and resource barriers for hearing-impaired college students, focusing on the translation gap between academic language and everyday sign

language. These include reading comprehension difficulties caused by highly abstract academic texts, the lack of corresponding expressions in sign language for overly abstract professional vocabulary, and severe shortage of adapted resources such as academic videos with accurate subtitles and research guides with sign language interpretation. All these factors hinder hearing-impaired students' deep digestion of information content and its application in academic writing.

Integrated strategy construction: On the basis of accurately identifying barriers, this study introduces information ecology theory as the core analytical framework, aiming to build a support system that goes beyond a single technology or service dimension and emphasizes multi-stakeholder collaboration. The strategy will be systematically designed around the four core elements of information ecology theory—people, technology, information, and environment—ensuring that the integrated strategy is both comprehensive in coverage and mutually supportive in practice, forming an organic whole.

1.3.2 Research methods

To ensure the systematic nature of the study and its value for practical guidance, this paper mainly adopts the literature research method and the case analysis method.

First, the literature research method: This method involves reviewing and analyzing relevant literature to understand the history, current status, and future development trends of the research object. This study will systematically collect and integrate journal articles, monographs, and research reports related to "information behavior of hearing-impaired students," "information ecology theory," and "support systems in higher education." This approach aims to build a solid theoretical foundation, extract common achievements and shortcomings, challenges, and development trends based on existing research results. Finally, combined with practical experience, successful cases and lessons from failures will be analyzed to provide references for proposing improvement measures and future development strategies.

Second, the case analysis method: This method involves analyzing specific cases to gain an in-depth understanding of the actual situation and problems of the research object, thereby providing a basis for solving problems and formulating policies. To avoid making the strategy construction too abstract, this study selects representative practical cases from universities, deeply analyzes the successful experiences and key factors behind them, and thus extracts generalizable successful experiences and transferable practice models.

2 RELATED CONCEPT DEFINITIONS AND THEORETICAL BASIS

2.1 Definition of Core Concepts

2.1.1 Hearing-impaired college students

"Hearing-impaired college students" generally refer to the academic group enrolled in higher education institutions who have hearing function impairments. Referring to the World Health Organization (WHO) hearing impairment classification standards and China's national standard Classification and Grading of Disabilities (GB/T 26341-2010), this study defines hearing impairment as organic or functional abnormalities in the central auditory system caused by congenital or acquired reasons, resulting in varying degrees of permanent hearing loss in both ears, making it difficult or impossible to hear environmental sounds and speech, thereby affecting daily life and social participation. Hearing-impaired college students, therefore, refer to those enrolled in higher education whose hearing impairment leads to persistent challenges in language comprehension and information reception.

The hearing-impaired group shows significant internal heterogeneity. According to the degree of hearing loss and language acquisition background, they can be mainly divided into two categories: (1) Deaf students: usually referring to students with hearing loss greater than 90 decibels, who primarily rely on sign language as their first language for communication. They often face conversion barriers between written language and sign language. (2) Hard-of-hearing students: referring to students with varying degrees of residual hearing. They may use devices such as hearing aids or cochlear implants, supplemented by lip reading and speechreading, to aid communication. Their information acquisition barriers may manifest in identifying and understanding complex auditory information, such as lectures and group discussions. This study covers both types of students because, although they differ in communication methods, they face similar and unique systemic barriers throughout the entire process of academic information acquisition.

2.1.2 Academic information acquisition

In this study, "academic information acquisition" refers to a series of behavioral processes in which college students identify, retrieve, understand, evaluate, and effectively use various types of academic information resources in order to complete their coursework and engage in research activities. It goes far beyond simply finding materials; rather, it is a comprehensive process involving both cognition and skills. The types of resources include academic journal articles, dissertations, monographs, course required readings, database resources such as CNKI and Web of Science, multimedia lectures, and academic conference reports. The behavioral process starts from the emergence of academic information needs, moves to information retrieval using tools such as the library OPAC system and databases, then proceeds to critical reading, understanding, and synthesis of the obtained information, and finally to its utilization in writing papers and completing assignments. For hearing-impaired college students, every step of this process can become extremely difficult due to the way information is presented, the mode of communication, and the accessibility of technical support.

2.1.3 Information barriers

In this study, "information barriers" is a multidimensional and comprehensive concept. It goes beyond the traditional scope of "physical barriers" such as wheelchair ramps. Specifically, it refers to the various difficulties encountered by

hearing-impaired college students throughout the entire process of academic information acquisition, caused by the mismatch between their own conditions and the external information environment. These barriers intertwine with each other and together constitute a barrier system that hinders their academic development. This concept mainly includes the following four levels:

- (1) Communication barriers: These arise from difficulties in language conversion, such as differences in grammatical structure between sign language and written/spoken language; the lack or insufficient standardization of specialized academic vocabulary in sign language systems; and limited depth of understanding of long sentences, complex logic, and metaphorical expressions.
- (2) Technological barriers: These refer to the absence or ineffective application of assistive technologies. For example, academic database platforms and learning management system interfaces are incompatible with screen readers and screen reading software; instructional videos lack captions or transcripts; and real-time speech-to-text services suffer from low accuracy and limited availability.
- (3) Information resource barriers: These refer to poor accessibility of the resources themselves. For instance, adapted academic resources such as videos explaining specialized knowledge points in sign language are extremely scarce; text resources use obscure language and lack simplified versions or reading guides; and resource discovery paths are complex without visual guidance.
- (4) Cognitive and service barriers: These refer to deficiencies in human resources and institutional support within the support system. For example, librarians and instructors lack awareness and professional skills for serving hearing-impaired students; there is a lack of effective coordination among the university library, disability student support center, IT department, and academic departments, leading to fragmented services.

2.2 Theoretical Basis

In order to systematically analyze the aforementioned complex and multidimensional barriers and construct an integrated support strategy, this study introduces information ecology theory as the core analytical framework. This theory was formally proposed by Bonnie Nardi and Eric S. Baker in 1996. It views the information environment as an organic ecosystem, emphasizing the interconnections and co-evolution among four core elements: people, information, technology, and environment. Traditional analytical approaches tend to examine technology, resources, or service issues in isolation, easily falling into the trap of addressing symptoms rather than root causes. The advantage of information ecology theory lies in its holistic and relational perspective. This theory suggests that the information acquisition problems of hearing-impaired college students are not caused by a single factor, but rather result from an imbalance in the entire information ecosystem. For example, even if advanced speech-to-text technology is introduced, if university librarians do not know how to guide students in using it, or if students are not required to ask instructors to provide captions, then the technology cannot function effectively. Therefore, information ecology theory is highly suitable as the theoretical foundation of this study, serving to reveal the deep-rooted causes of barriers and guide the construction of a supportive information ecosystem in which all elements interact positively.

This study strictly follows the four-element framework of information ecology theory, analyzing barriers and constructing support strategies for hearing-impaired college students' academic information acquisition within this framework. The details are as follows:

- (1) People: This refers to the various roles within the information ecosystem. It includes not only the main subjects of information use—hearing-impaired college students, whose information literacy and communication preferences are crucial—but also university librarians, subject instructors, sign language interpreters, volunteers, and others. The quality of interaction among these roles directly determines the efficiency of information transmission.
- (2) Information: This refers to the content, structure, and presentation form of academic information resources themselves. For example, whether the format is plain text, audio, or video; whether synchronized captions, transcripts, or sign language interpretation are provided; whether the information organization structure is clear; whether the language difficulty is appropriate. The accessibility of information is the focus of this element.
- (3) Technology: This refers to the various hardware tools and platforms used in the information acquisition process. It includes assistive technologies, such as real-time captioning systems like iFlytek Hearing, sign language translation apps, screen magnification software, and high-definition video calling equipment. It also includes basic technologies, such as the accessibility design level of library retrieval systems, database platforms, and academic websites.
- (4) Environment: This refers to contextual factors surrounding information activities, including policies, culture, institutional arrangements, and physical spaces. This includes national and institutional accessibility laws and policies, the inclusive cultural atmosphere advocated on campus, institutional arrangements for cross-departmental collaboration, and accessible facilities in the library's physical space. The environmental element provides the background and rules for the interaction of the other three elements.

3 CORE BARRIER ANALYSIS OF ACADEMIC INFORMATION ACQUISITION FOR HEARING-IMPAIRED COLLEGE STUDENTS

According to the framework of information ecology theory, the barriers faced by hearing-impaired college students in the process of academic information acquisition do not exist in isolation in any single aspect. Instead, they represent a comprehensive manifestation of the imbalance in the interaction among the four elements: people, technology,

information, and environment. Through a systematic review of existing literature, this study conducts an in-depth analysis of the core barriers to academic information acquisition for hearing-impaired college students from four dimensions: information communication, technology and environment, information resources, and support services.

3.1 Information Communication Barriers

Communication barriers are the primary and most direct challenge faced by hearing-impaired college students in the process of academic information acquisition, mainly reflected in language conversion, understanding of specialized vocabulary, and deep processing of textual information.

First, the conversion between sign language and mainstream written language as well as academic language is very difficult, constituting the most fundamental barrier to academic information acquisition for hearing-impaired college students. As a visual-spatial language, sign language has significant differences in grammatical structure and logical expression compared with Chinese written language. When reading written materials such as academic literature and textbooks, hearing-impaired college students often need to perform a language conversion in their minds for thinking. This process not only consumes substantial cognitive resources but also easily leads to misunderstandings due to mismatched grammatical structures. For example, complex long sentences, passive voice, and abstract concepts lack direct corresponding expressions in sign language, resulting in low decoding efficiency and impaired accuracy.

Second, the lack of specialized academic vocabulary in sign language systems is particularly prominent. A large number of specialized terms and concepts in various academic disciplines have not yet formed unified and standardized expressions in sign language, which constitutes a knowledge bottleneck for deaf students in receiving higher education. When course content or academic literature involves cutting-edge theories or proper nouns, even proficient sign language users may face gaps in expression and understanding. This places deaf students at a disadvantage when participating in academic discussions and understanding the core content of specialized lectures, seriously affecting their deep construction of disciplinary knowledge.

Furthermore, the depth of understanding of purely textual information is generally insufficient. Studies have shown that the average developmental level of written language reading ability of congenitally or early-deafened students usually lags behind that of their hearing peers of the same age. Academic texts are typically characterized by high density, strong abstraction, and rigorous logic, requiring readers to possess high-level language decoding and reasoning abilities. Hearing-impaired students often find this challenging, having difficulty accurately grasping the implied meaning, argumentation logic, and author's intention of the text, thus affecting the effective absorption and utilization of academic information. Lan Zebo et al. found through eye-tracking experiments that there are differences in the phonological processing mechanisms during sentence reading between hearing-impaired college students and hearing students [7], revealing from a cognitive perspective the inherent difficulties they face in processing written information. Yang Xue's study further pointed out that reading ability moderates the phonological encoding of hearing-impaired college students [8], and those with lower reading ability face more severe challenges when processing textual information.

3.2 Technology and Environmental Barriers

The lack of accessible design in technological tools and insufficient supporting environments greatly limit the opportunities for hearing-impaired college students to equally access academic information.

At the technological level, mainstream academic database platforms, library retrieval systems, and online learning management systems often lack adequate accessibility considerations. Geng Manman's survey of North American research libraries reflects that many university libraries in China have obvious shortcomings in accessibility [9], such as poor compatibility of interfaces with screen readers and lack of keyboard navigation support, failing to fully consider the needs of visually and hearing-impaired users. In addition, audiovisual materials containing substantial valuable content, such as video lectures and academic interviews, commonly lack synchronized captions or written transcripts, preventing hearing-impaired students from accessing their core content. Bai Ruixia pointed out from a media ecology perspective that the current information dissemination environment exhibits "media discrimination" against the hearing-impaired group and a "lack of supply in communication production," with technological barriers artificially creating a "digital divide" in information acquisition [10].

At the environmental level, inadequate provision of assistive technologies on campus, poor maintenance, and lack of usage training are common phenomena. Although the national standard GB/T 40952-2021 Service Specification for Hearing-Impaired Persons in Public Libraries has set clear requirements for equipment and facilities (such as hearing assistance systems and information communication devices) in library services for hearing-impaired individuals, the actual implementation varies greatly. More importantly, hearing-impaired students and teaching support staff often lack systematic operational training, resulting in low utilization rates of advanced technological equipment and failure to achieve their intended effectiveness. Zhang Xingwang et al. noted that the absence or slow response of technical support teams also prevents rapid resolution of technical problems [11], further exacerbating difficulties in information acquisition. In their review of intelligent interaction technologies for digital library information accessibility, Zhang Xingwang et al. also pointed out that the application and diffusion of technology heavily depend on supporting environments and training support [11], which are precisely the weak links in current universities.

3.3 Information Resource Barriers

The scarcity of adapted academic resources and the complexity of resource discovery paths constitute content-level barriers to information acquisition for hearing-impaired college students.

Severe shortage of adapted resources is a core issue. Currently, the vast majority of academic resources exist in the form of plain text or uncaptioned audio/video. Resources specifically tailored for hearing-impaired learners that match their cognitive characteristics are extremely rare. For example, although some publications interpreting traditional culture in sign language have emerged, adapted resources such as academic video libraries providing systematic explanations in sign language for various higher education disciplines, or summary guides and simplified texts for complex literature, remain extremely scarce. Bai Ruixia's study pointed out that the content production side lacks proactive awareness of providing accessible information services for the hearing-impaired group, leading to a serious shortage of adapted resource supply [10]. This homogeneity of resource formats fails to meet the diverse information processing preferences and learning needs of hearing-impaired students, forcing them to rely on limited, possibly suboptimal channels for learning.

Resource discovery and acquisition paths are complex and unfriendly. Library retrieval systems have high operational thresholds for hearing-impaired students unfamiliar with professional search strategies. Metadata descriptions may not be intuitive enough, and there is a lack of visual or guided retrieval interfaces. Meanwhile, electronic resources scattered across different platforms requiring complex authentication increase the difficulty of navigation and access. Liu Qin and Guo Ling's survey of 225 hearing-impaired college students from five domestic universities found that they visit libraries infrequently and seldom utilize library resources [12], with most attributing this to "insufficient external environment and support," including difficulties in resource discovery and acquisition. When searching for specific materials, hearing-impaired students often need to spend more time and effort than their hearing peers and are prone to abandoning in-depth exploration due to frustration in the process.

3.4 Support Service Barriers

Effective support services are key to compensating for individual ability limitations and technological constraints. However, the current support system within universities has obvious shortcomings.

University librarians and other frontline service personnel who directly interact with students generally lack professional knowledge and communication skills for serving hearing-impaired users. Most librarians have not received basic training in sign language, deaf culture awareness, or guidance on assistive technology applications. This makes it difficult for them to communicate effectively with hearing-impaired students when providing reference consultations, information literacy education, or retrieval guidance, and to accurately identify and meet their special information needs. Services often remain at a basic level. Lin Yirong and Shu Man found through a survey of Canadian university libraries that establishing dedicated departments with specially trained professionals is key to providing effective services for disabled students [13], which is exactly what many domestic universities lack.

The cross-departmental collaborative service mechanism within universities is underdeveloped, resulting in fragmented support. Academic information support for hearing-impaired college students involves multiple entities, including the library, disability student support center, information technology department, college teaching and research offices, and student organizations. However, in reality, these departments often lack smooth communication channels and clear division of responsibilities, with insufficient information sharing and difficulty in coordinating actions. Geng Manman's study also pointed out that Chinese university libraries have not yet established a collaborative support network comparable to those in some North American universities [9], one led by the library and deeply integrating multiple campus resources for serving disabled readers. As a result, the services provided to hearing-impaired students are often fragmented, passive, and reactive, rather than a forward-looking, systematic, and seamlessly connected support network, making it difficult to address the complex challenges throughout the entire process of academic information acquisition. In summary, the barriers faced by hearing-impaired college students in academic information acquisition constitute a multidimensional and systemic problem chain. Information communication barriers affect the accuracy of information decoding; technology and environmental barriers create obstacles at both physical and digital levels; information resource barriers limit the quality and format of available content; and support service barriers weaken the effectiveness of external assistance. These barriers intertwine with each other, collectively forming a realistic predicament for the academic development of hearing-impaired college students, while also providing clear targets and foundations for subsequently constructing integrated support strategies based on information ecology theory.

4 CASE ANALYSIS AND IMPLICATIONS OF DOMESTIC AND INTERNATIONAL UNIVERSITY SUPPORT FOR HEARING-IMPAIRED STUDENTS' ACADEMIC INFORMATION ACQUISITION

4.1 Principles of Case Selection

To ensure the depth and referential value of the case analysis, the cases selected in this chapter follow the principles below:

Representativeness: Cases are selected from universities that have broad recognition and mature systems in providing support services for hearing-impaired students. Their practices can reflect the mainstream model and development level of a particular country or region.

Innovativeness: Special attention is given to cases with outstanding innovative measures in service concepts, technology application, or cross-departmental collaboration, so as to provide forward-looking ideas for strategy construction.

Transferability: The selected cases have operability and portability in terms of institutional design, resource allocation, and specific service programs, offering practical and feasible reference paths for university libraries and related departments in China.

Based on the above principles, this chapter selects Syracuse University Library in the United States as an international case, which is renowned for its well-established accessibility service system, advanced technology, and deep integration with teaching [14]. For a domestic case, Tianjin University of Technology Library is selected, as it has carried out systematic localized explorations in personalized services for hearing-impaired students (especially those in its Deaf Engineering College), demonstrating distinctive practical features [14].

4.2 Case Study One: Construction of the Accessibility Service System at Syracuse University Library

4.2.1 Detailed case analysis

Syracuse University Library has built an accessibility service system that is institutionally guaranteed, supported by advanced technology, and deeply integrated with campus academic life, providing comprehensive support for hearing-impaired students in their academic information acquisition.

(1) Well-Established Institutional and Collaborative Support Mechanisms

Syracuse University regards accessibility as a core campus-wide commitment. The library's services do not operate in isolation but are embedded within the university's overall "Accessible Syracuse" framework. The university has established a Disability Resource Center, which coordinates accessibility services across the entire campus. Students must register with this center to receive reasonable accommodation arrangements. Within this framework, the library works closely with the center, clarifying their respective responsibilities to ensure smooth connections from policy to implementation. For example, the library's "Alternative Format Service" clearly stipulates that it only provides accessible format conversion of collection resources for students and faculty who are registered and authorized by the Disability Resource Center and require such services for coursework or academic research. This institutionalized collaborative mechanism ensures the standardization and sustainability of services.

(2) Professional Assistive Technology Center and Resources

The Bird Library houses the "Joel and Barbara Zelnick Assistive Technology Room," a resource center specifically designed for students with disabilities. This technology room is equipped with industry-leading assistive hardware and software, forming a powerful technology empowerment matrix:

Reading and Writing Support: It provides Kurzweil 3000 and Kurzweil 1000 software, which can read scanned text or digital documents aloud in real time, with functions such as text highlighting, spell checking, summary generation, and outline extraction. These features greatly assist hearing-impaired students in understanding and processing complex academic texts.

Screen Reading and Magnification: Workstations are pre-installed with JAWS screen reader and ZoomText magnification software, ensuring that hearing-impaired students can independently operate computers and access various databases and online academic resources.

Portable Devices: The library offers PEARL portable reading cameras, which students can borrow and use anywhere to scan books or documents, with instant read-aloud functionality through accompanying software, breaking the limitations of learning spaces.

Sensory-Friendly Environment: The library has also set up a "Sensory-Friendly Study Room," equipped with adjustable lighting, noise-canceling headphones, and stress-relief toys, creating a focused and low-pressure learning space for hearing-impaired students who are sensitive to sound and light.

(3) Real-Time Captioning and Communication Services Deeply Integrated with Coursework

The university and its library deeply integrate real-time information conversion technology into academic scenarios. At the university level, large events such as freshman orientation all provide CART (real-time speech-to-text transcription) and ASL (American Sign Language) interpretation services. More importantly, this support extends to daily academic information acquisition. The library directly provides captioning services for many of its subscribed video resource packages. Meanwhile, with the development of AI technology, functions such as WPS AI's "real-time simultaneous captioning" can achieve low-cost real-time transcription of speech in face-to-face communication, lectures, and online meetings, providing key technical support for hearing-impaired students to understand classroom content and participate in academic discussions. This essentially constructs a closed loop of "information accessibility" ranging from course resources to real-time interaction.

4.2.2 Analysis of how the case practices alleviate core barriers

The practices of Syracuse University systematically respond to the multiple barriers described in Chapter Three of this paper:

(1) Addressing information communication barriers: The provision of CART real-time speech-to-text transcription and ASL interpretation directly alleviates the difficulties of language conversion and specialized vocabulary comprehension in classrooms and lectures. The summary generation function of Kurzweil software assists in understanding complex texts.

(2) Addressing technology and environmental barriers: The establishment of an assistive technology room equipped with professional software such as JAWS and ZoomText, along with ensuring that subscribed resources contain captions, directly solves the problems of poor compatibility between database platforms and assistive technologies, as well as the lack of captions in audiovisual resources. The Information and Communication Technology Accessibility

Policy removes technological and environmental barriers at the institutional level.

(3) Addressing information resource barriers: The "Alternative Format Service" converts library collection resources into accessible formats on demand, creating adapted resources. The default provision of captions in video resources improves the accessibility of general resources.

(4) Addressing support service barriers: The institutionalized collaboration between the library and the university-wide Disability Resource Center, together with assistive technology training for librarians, effectively resolves the problems of fragmented support services and the shortage of professional personnel.

4.3 Case Study Two: Service Practices for Hearing-Impaired Students at Tianjin University of Technology Library

4.3.1 Detailed case analysis

The Deaf Engineering College of Tianjin University of Technology is an important base for higher special education in China. Its library has carried out a series of targeted service explorations around the specific needs of hearing-impaired students, reflecting a shift from "general services" to "precise support."

(1) Development of Sign Language Resources and Exploration of Visual Services

Recognizing the significant visual advantages of hearing-impaired students, the library actively explores "visual reading" services, that is, conveying information through non-text forms such as images, charts, and visualized processes. Some studies have pointed out that libraries should develop visual and image-based service strategies to help hearing-impaired readers access information resources more equitably [15]. In practice, when communicating with hearing-impaired students, librarians at Tianjin University of Technology not only rely on written text but also emphasize the use of intuitive methods such as diagrams and demonstrations. At the same time, the library actively pays attention to and introduces high-quality sign language academic resources. For example, the Chinese Sign Language Series (Audio-Visual Edition) launched by Professor Zheng Xuan's team from the School of Special Education at Beijing Normal University interprets classics in the form of "text introduction plus sign language video." Such resources are of great significance for filling the gaps in hearing-impaired students' higher-level academic sign language vocabulary and improving their cultural literacy. The library's procurement and promotion of such resources itself constitutes an important effort in building adapted academic resources.

(2) Customization and Humanization of Information Literacy Education

The library has realized that the general information retrieval courses designed for all ordinary students on campus cannot meet the learning characteristics of hearing-impaired students. Surveys show that only 15% of hearing-impaired students at the Deaf Engineering College believe they can fully obtain the information they need from the library, while 68% think they can basically do so. To some extent, this reflects that there is still room for improvement in their information awareness and utilization ability [16]. To address this, the library has developed customized training services. For example, when hearing-impaired students have difficulty understanding database training sessions, librarians proactively contact sign language interpreters for assistance or use real-time translation software to ensure the training content is effectively conveyed. This model of "professional training plus real-time assistance" reflects the humanization and precision of services. Librarians summarized that it is necessary to "start from the small details and consider every need of theirs," communicating and guiding through methods such as preparing sticky notes and patiently demonstrating [16].

(3) Cross-Departmental Collaborative Service Mechanism

The practices at Tianjin University of Technology demonstrate that effective support for hearing-impaired students requires collaboration among multiple parties, including the library, the college (Deaf Engineering College), and the information technology department. The library's service explorations have received support from teaching fund projects, which itself reflects cross-departmental collaboration. In specific services, the library maintains close communication with the Deaf Engineering College to understand students' course progress and academic needs (such as thesis writing, certificate examinations, etc.), thereby providing proactive resource recommendations and guidance. In addition, to address the accessibility issues of online course resources such as MOOCs, the library has attempted to provide "MOOC supplementary subtitle services," which require cooperation with course providers and the information technology department to jointly overcome technical and managerial challenges. Although this collaborative mechanism is still being explored, its direction clearly indicates that building a support system must break down departmental barriers [15].

4.3.2 Analysis of how the case practices alleviate core barriers

(1) Addressing information communication and information resource barriers: The introduction of sign language academic resources such as the Chinese Sign Language Series and the exploration of "visual reading" services directly respond to the problems of lacking specialized sign language vocabulary and scarcity of adapted resources, utilizing visual advantages to assist comprehension.

(2) Addressing technology and environmental barriers: Attempts to add supplementary subtitles to MOOCs and apply low-cost tools such as WPS AI real-time captioning represent flexible and practical solutions to the common technological barrier of missing captions in video resources.

(3) Addressing support service barriers: Customized information literacy education (supplemented by sign language interpreters or translation software), along with cross-departmental collaboration explorations with the Deaf Engineering College and the IT department, reflect efforts to enhance the service capacity of "people" and break down

departmental silos to overcome fragmented services.

4.4 Case Comparison and Implications

Building on the case descriptions and the analysis of barrier alleviation presented above, this section compares the two cases from the perspective of the four-element framework of information ecology theory — “people, technology, information, and environment.” The aim is to distill how these cases systematically address deaf students’ barriers to accessing academic information, and to offer actionable insights for Chinese higher education institutions. The following is a systematic comparison based on obstacle mitigation:

The practices of Syracuse University and Tianjin University of Technology have respectively responded systematically to the barriers described in Chapter 3 through two pathways: “institutionalized top-level design” and “service-oriented targeted innovation” (see **Table 1**). Syracuse University’s system comprehensively covers all four categories of barriers, establishing high-standard guarantees at the environmental and technological levels, particularly through mandatory policies and specialized centers. In contrast, Tianjin University of Technology’s exploration demonstrates how, under existing resource constraints, it achieves breakthroughs on core barriers by enhancing human agency, flexibly applying low-cost technologies, and actively building adapted information resources. The common core of both approaches is that they transcend fragmented services provided by individual departments and strive to construct a collaborative mechanism.

Table 1 Comparison of Practices and Barrier Alleviation Based on the Information Ecology Framework: Domestic and International Cases

Dimension	Syracuse University Library (International Case)	Tianjin University of Technology Library (Domestic Case)	Insights and Directions for Reference
People	Dedicated accessibility service librarians; collaboration with the university-wide Disability Resource Center professional team; training librarians in assistive technology	Librarians demonstrate strong service awareness and empathy, proactively learn communication skills with deaf students (e.g., using translation apps, visual aids); collaborate with teachers from the Deaf Engineering College and sign language interpreters	Insight: Professional personnel are the core of service. It requires not only librarians' awareness and basic skills in accessibility but also external collaboration with special education experts, sign language interpreters, and IT technicians. Reference: Establish a joint service team of “librarian + special education teacher/sign language interpreter + student volunteer,” and provide systematic training on accessibility service standards and assistive technology operations for librarians.
Technology	Established centralized, well-equipped assistive technology labs (e.g., Kurzweil, JAWS); provides portable assistive devices (e.g., PEARL camera); extensive integration of captions in video resources; uses real-time transcription technologies such as CART	Explores real-time translation software for auxiliary training; attempts to add external subtitles to MOOCs; focuses on and applies low-cost AI tools like WPS AI real-time captioning	Insight: Technology is a key tool for removing barriers. Services should extend from “fixed workstations” to “portable + cloud-based” solutions, and shift from “remedial measures” (e.g., format conversion) to “embedded pre-planning” (e.g., resources with built-in captions). Reference: Plan and build an assistive technology space integrating hardware, software, and training; prioritize including accessibility clauses in contracts for electronic resources purchased by the library; promote lightweight real-time captioning solutions suitable for lectures, seminars, and consultation scenarios.
Information	Converts library resources into accessible formats on demand through “alternative format services”; ensures subscribed databases and video resources are accessible	Focuses on developing and introducing visual learning resources; pays attention to and procures adapted resources such as sign language academic videos; enhances students' information literacy through customized training	Insight: The accessibility and comprehensibility of information resources themselves are equally important. General resources need accessibility transformation, while dedicated resources tailored to the cognitive characteristics of deaf students must be actively developed. Reference: Develop a workflow for

			accessibility transformation of library collections; collaborate with the School of Special Education to co-build a "Sign Language Academic Video Library" or "Discipline Knowledge Visualization Map"; compile an illustrated Library Use Guide for deaf students.
			Insight: Top-level institutional design and cultural atmosphere are the fundamental guarantees for sustainable services. Without mandatory policies, services tend to become fragmented and dependent on individuals.
Environent	Has a unified university-wide Information and Communication Technology Accessibility Policy mandating digital content accessibility; campus culture emphasizes inclusion and equity; physical spaces include sensory-friendly study rooms	Service practices are supported by university teaching reform projects; campus culture advocates care and inclusion for deaf students; the library gradually fosters a proactive service atmosphere	Reference: Promote the formulation of a Campus Information Accessibility Construction Regulation at the university level, clarifying responsibilities of the library, academic affairs office, and IT department; incorporate universal design principles in library space renovation; foster a campus-wide inclusive culture through promotional activities.

In summary, the two cases validate from different perspectives the effectiveness of constructing a support system based on information ecology theory. The experience of Syracuse University demonstrates that systematic, institutionalized top-level design combined with strong technological empowerment can create a stable, comprehensive, and predictable support environment, systematically reducing barriers at their root. The exploration of Tianjin University of Technology reveals that, within the existing institutional framework, significant results can also be achieved through "people-centered" service awareness innovation, precise needs responsiveness, and initial cross-departmental collaboration — a path that offers greater flexibility and immediate operability.

What both cases point to is this: support for deaf students' access to academic information must be elevated from a "special service" or "welfare" provided by a single department to a "systematic project" requiring multi-departmental collaboration across the entire university and positive interaction among all ecological elements. This demands that universities not only introduce certain technologies or conduct specific trainings, but also establish institutional safeguards in the environment, ensure universal accessibility in technology, provide adapted content in information, and ultimately link these elements together through human coordination and execution. This perspective of an "ecosystem engineering" approach provides a solid empirical foundation and logical starting point for constructing an integrated support strategy in Chapter Five.

5 STRATEGY DEVELOPMENT FOR SUPPORTING DEAF COLLEGE STUDENTS' ACCESS TO ACADEMIC INFORMATION

Based on information ecology theory and the insights derived from the preceding case studies, the construction of an academic information support system for deaf college students must ensure the synergistic evolution of the four elements — "people, technology, information, and environment." This chapter proposes a phased, actionable strategic implementation framework, aiming to provide higher education institutions with a clear pathway progressing from simple to complex and from pilot initiatives to broader application, thereby enhancing the practical guiding value of the strategies.

5.1 Optimizing the "Information Ecology" Environment: A Gradual Path Toward Institutional and Cultural Safeguards

The optimization of environmental elements serves as the foundation of the support system and should progress from advocacy and coordination toward institutionalization.

5.1.1 Short-term strategy (implementable within one year)

The core task is to initiate advocacy and develop internal norms. University libraries may take the lead in establishing an accessibility service team, formulating and publishing a Service Guide for Deaf Readers, and organizing an "Accessibility Service Awareness Week" campaign to raise campus-wide awareness. At this stage, costs are relatively low, primarily consisting of staff hours and publicity expenses. Potential resistance lies in the increased workload for librarians initially, which may reduce the service to mere formality. Therefore, library leadership must take the initiative, and relevant service responses should be incorporated into performance considerations.

5.1.2 Medium-term strategy (requiring 1–3 years of cross-departmental coordination)

The key is to establish a university-level collaborative mechanism. Efforts should be made to set up an "Accessibility

Service Task Force" composed of representatives from the library, academic affairs office, IT department, student affairs division, and the school of special education (if applicable), and to formulate an Interim Standard for Accessibility in Campus Digital Resource Procurement. This phase involves moderate coordination and standard-setting costs. The main obstacles are unclear departmental responsibilities and insufficient willingness to collaborate. It is essential to secure oversight from university-level leadership and to clearly define the task force's charter and output goals.

5.1.3 Long-term strategy (requiring over three years of policy and funding support)

The goal is to achieve institutionalization and normalization. Universities should strive to incorporate "information accessibility" into the overall plan and budget for campus informatization, issue a mandatory Campus Information Accessibility Regulation, and include the design of sensory-friendly learning spaces in infrastructure planning. This phase demands a high level of commitment to institutional change and sustained financial support. Resistance arises from competition with other institutional priorities. The key to success lies in accumulating outcome data from short- and medium-term practices, which can serve as empirical evidence to secure top-level policy backing.

5.2 Strengthening "Technology" Empowerment: Building a Smart Assistive Support System

Technology serves as a direct tool for removing barriers, and its application should evolve from lightweight assistance toward systematic empowerment.

5.2.1 Short-term strategy

The focus is on rapidly deploying lightweight real-time assistive tools. Devices pre-installed with iFlytek Hearing (Xunfei Tingjian) or utilizing the "WPS AI Together Hearing" public welfare program can be set up at library information desks and electronic reading rooms, along with promoting free real-time captioning mobile apps. Costs are relatively low, but attention must be paid to potential operational unfamiliarity among librarians and students, as well as accuracy limitations of these tools in complex scenarios. The key implementation measure is to hold small-scale workshops to train librarians as "technology promoters."

5.2.2 Medium-term strategy

The emphasis shifts toward building an integrated assistive technology space. It is recommended to designate an "Assistive Technology Learning Zone" within the library, equipped with Kurzweil reading software, high-definition video calling devices (for remote sign language interpretation), and portable text scanners. This phase requires moderate investment in space renovation and hardware/software procurement. The greatest risk is that low equipment utilization may lead to sunk maintenance costs. Therefore, a supporting system of reservation, training, and dedicated personnel (or student assistants) for maintenance must be established. Co-building and co-managing this space with the campus disability support center may also be considered.

5.2.3 Long-term strategy

The focus turns to empowering universal platforms and ecosystems. Accessibility design should be made a mandatory technical requirement for all newly procured or self-built information systems (such as learning management systems and databases). Meanwhile, collaboration with technology companies or universities with relevant disciplines could be explored to develop professional sign language real-time translation systems better suited to the Chinese context. This requires a high degree of policy enforcement and potential R&D investment, and its feasibility depends heavily on the establishment of long-term institutional mechanisms within the "environment" element.

5.3 Innovating "Information" Resource Development: Building Adapted Academic Resources

Information resource development must balance "accessibility" with "comprehensibility," evolving from internal adaptation toward standard-setting leadership.

5.3.1 Short-term strategy

Start by initiating the accessibility transformation of existing resources. Libraries should mandate captioning for self-produced or library-led instructional videos and lecture recordings, and create illustrated Visual Search Guides for frequently used databases. The main cost lies in labor, and the primary challenge is the time-consuming nature of subtitle production. This can be addressed by recruiting student volunteers to form a "subtitle team" or by incorporating the task into relevant course practice projects.

5.3.2 Medium-term strategy

Focus on systematically building an adapted resource repository. Libraries can collaborate with schools of special education and academic departments to co-develop a "Sign Language Academic Video Library," inviting faculty members or outstanding deaf students to explain core concepts and classic literature, while systematically producing summary guides for classic textbooks in the collection. This phase involves moderate project coordination and content production costs. The key is to motivate faculty participation and ensure the professionalism of sign language explanations. This effort can be submitted as a university-level teaching reform project, with a review mechanism established involving special education experts, subject faculty, and deaf students.

5.3.3 Long-term strategy

Aim to achieve full coverage of accessibility resource standards. The goal is to mandate university-wide that all newly produced public instructional resources (such as MOOCs and open lectures) must include captions and transcripts, and to promote the establishment of an inter-university sign language academic resource alliance. This phase primarily involves costs related to policy supervision and alliance coordination. The greatest challenge lies in covering all

departments and ensuring compliance. This requirement must be deeply integrated with the course development and evaluation standards of the academic affairs office and graduate schools.

5.4 Enhancing "People" Service Capacity: Strengthening Professional Team Building and Multi-stakeholder Collaboration

People are the core element linking all components together, and the focus of support should expand from individual capacity building to ecosystem cultivation.

5.4.1 Short-term strategy

Focus on empowering the core service team. Mandatory "Basic Accessibility Service Training" should be provided to frontline librarians and reference librarians, covering deaf culture awareness, basic communication skills, and the use of existing assistive tools. Costs are low, but care must be taken to prevent librarians from viewing this as an additional burden. Training should be concrete and scenario-based, and may be supplemented with simple internal certification to enhance effectiveness.

5.4.2 Medium-term strategy

The key lies in establishing a stable cross-departmental collaboration network. A quarterly joint meeting system for the "Accessibility Service Task Force" should be institutionalized, a cross-departmental "work order routing" system for deaf students' service needs should be established, and efforts may be made to jointly offer a required or elective course titled Academic Information Literacy for Deaf Students. This phase involves moderate organizational and development costs. Resistance may arise from work orders being passed between departments and the complexity of course credit recognition. Implementation requires clear response timelines and a first-contact responsibility system for work orders, while the course may first be piloted in workshop format.

5.4.3 Long-term strategy

The goal is to cultivate a specialized support ecosystem. When conditions permit, a permanent "Accessibility Service Specialist" position should be established within the library or disability support center, and a stable team of sign language interpreter volunteers or employees with specific domain knowledge (e.g., law, medicine) should be cultivated. This is the most costly strategy, involving new staffing positions and professional salaries. The greatest challenge lies in sustained financial investment, which must be justified by long-term service data demonstrating efficiency gains and risk reduction brought about by specialization and professionalization, thereby making a strong case for new positions.

The above element-specific, multi-tiered implementation framework demonstrates that building an effective support system is a gradual, systematic project. Higher education institutions may start with "short-term" strategies based on their own resource endowments, quickly establishing service highlights and building consensus, before progressively moving toward "medium- and long-term" strategies that require institutional change and resource investment. It must be noted that the strategies for the four elements — people, technology, information, and environment — need to complement each other and evolve synergistically. For example, the implementation of "technology" tools cannot succeed without "people" training and promotion, and the effectiveness of "information" resource development requires the mandatory safeguard of "environment" policies. Only by adhering to a systemic perspective and promoting positive interaction among the four elements can a sustainable, efficient, and truly deaf-student-centered academic information accessibility ecosystem be ultimately constructed.

6 CONCLUSION AND OUTLOOK

6.1 Research Conclusions

This study, employing the "information ecology" theory as its analytical framework, systematically explores the core barriers faced by deaf college students in accessing academic information and constructs a corresponding support strategy system. The main findings are as follows:

First, the barriers to academic information access for deaf college students constitute a multi-layered, systemic problem, primarily manifested in four dimensions: (1) Information communication barriers: Difficulties in converting between sign language and written language, and comprehension gaps caused by the lack of sign language equivalents for specialized academic vocabulary, represent the core cognitive obstacles affecting deep information processing. (2) Technology and environmental barriers: Academic databases and library systems generally lack accessibility design, and campus assistive technologies (such as high-quality real-time captioning) are inadequately equipped or lack proper training, creating physical and technological barriers. (3) Information resource barriers: Adapted resources (such as academic videos with standard sign language interpretation and guided reading texts for complex literature) are extremely scarce, and resource acquisition pathways are complicated, failing to meet deaf students' unique cognitive and perceptual needs. (4) Support service barriers: Support personnel such as librarians lack professional service skills, and coordination mechanisms among various campus departments (library, special education center, IT department, academic faculties) are ineffective, resulting in fragmented support services and delayed responses.

Second, in response to the above barriers, building a multi-stakeholder collaborative support system is crucial. The support strategies proposed in this study closely revolve around the four elements of information ecology — "people, technology, information, and environment": (1) Optimizing the "environment": By formulating mandatory campus information accessibility policies and fostering an inclusive culture, provide fundamental safeguards at the institutional and cultural top level. (2) Strengthening "technology": Promote and deploy mature, low-cost real-time speech-to-text

technologies such as iFlytek Hearing (Xunfei Tingjian) and FunASR, and develop accessible search tools to directly empower information communication through technology. (3) Innovating "information": Focus on building a sign language academic video library, mandating captions for instructional resources, and providing guided summaries of academic literature to increase the supply of adapted academic resources at the source. (4) Enhancing "people" capacity: Strengthen accessibility service training for librarians, and establish normalized cross-departmental coordination mechanisms involving the library, school of special education, IT department, and student organizations, ensuring the professionalism and sustainability of support services.

6.2 Research Innovations and Limitations

The innovations of this study are mainly reflected in the following aspects:

Innovative application of theoretical perspective: The "information ecology" theory is systematically introduced into the research field of deaf college students' information behavior. This moves beyond the isolated view of barriers and instead treats "people, technology, information, and environment" as an interacting whole, providing a powerful analytical framework for systematic problem analysis and integrated strategy construction.

Systematic and operational nature of strategy construction: The proposed support strategies are not scattered recommendations but rather form a coherently interconnected strategy system covering multiple dimensions — institution, technology, resources, and services — grounded in theoretical frameworks and case analysis. The strategies draw on specific practices from domestic and international universities (such as Nanjing Normal University of Special Education, Tianjin University of Technology, and Zhejiang University Library), offering strong reference value and practical applicability.

The limitations of this study are mainly as follows:

Limitations of research methods: This study primarily adopts literature review and case analysis methods. While these allow for systematic identification of issues and drawing on exemplary practices, the study lacks first-hand empirical data collection and analysis from deaf college students (such as in-depth interviews, surveys, and behavioral observations). Consequently, the nuanced experience of barriers, the effectiveness of strategies, and priority judgments are mainly based on secondary literature and publicly available cases, and their precision awaits further validation through empirical research.

Insufficient differentiation of research subjects: Within the group of deaf college students, there exist variations in hearing loss severity, educational background, major discipline, and degree of sign language reliance. The conclusions and strategies of this study are more directed toward shared challenges and do not delve deeply into the specific differences in academic information needs and behavioral patterns among different subgroups (e.g., STEM vs. humanities and social sciences students). While the proposed strategies possess strong general applicability, individualized considerations merit further refinement.

6.3 Future Outlook

Based on the findings and limitations of this study, future research may be further deepened in the following areas:

Conducting empirical research to obtain first-hand data: Future research should adopt mixed-methods approaches, conducting in-depth interviews, surveys, or behavioral experiments with deaf college students from multiple universities to directly capture their authentic experiences, specific difficulties, and preference needs in the process of academic information access. This will provide empirical support and revision grounds for the barrier analysis and strategy hypotheses proposed in this study.

Deepening research on intra-group differences: Comparative studies may focus on deaf students with different disciplinary backgrounds (e.g., medicine, engineering, arts), varying degrees of hearing loss (profound deafness, hard of hearing), or different communication modes (primarily using sign language, primarily relying on spoken language and lip-reading). Exploring similarities and differences in their information behavior patterns would enable the proposal of support plans that are more discipline-specific and individually adaptive.

Tracking and evaluating the effects and ethics of technology applications: With the rapid development of technologies such as AI translation, real-time captioning, and virtual sign language avatars, future research should continuously track the actual application effects of these technologies in academic settings, user experiences, and potential new technological barriers (e.g., the impact of error rates and latency on comprehension). At the same time, ethical issues such as information equity and data privacy arising from technological dependence warrant attention.

Exploring the construction of an "inclusive" support service model: Future research on support systems should not be limited to "special services" alone. Instead, greater exploration should be directed toward how to deeply integrate accessibility design into the general services of university libraries, curriculum design, and the campus information environment. The goal is to construct a truly inclusive academic information support ecosystem that benefits all students — including those who are deaf, visually impaired, or have other temporary needs.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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