

Exploring the implementation of artificial intelligence applications among academic libraries in Taiwan

The
implementation
of AI in
libraries

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Abstract

Purpose – This study explored the different artificial intelligence (AI) applications used in academic libraries and the key factors and impediments related to their implementation.

Design/methodology/approach – The author applied quantitative research methods in the form of a questionnaire, using both open and closed questions. A total of 472 valid questionnaires were received from academic librarians.

Findings – The author sought responses from librarians who had implemented AI applications and those who had not, identifying the types of AI applications implemented, key factors relating to their implementation, and impediments to promoting AI. Gaps were identified between the level of support for AI applications and the negative effect of the impediments. Furthermore, the more extensive the individual and organizational knowledge activities performed by the librarians and libraries held, the more positive the attitude was librarians' attitude toward AI applications in their libraries. However, librarians recognized that AI applications are inevitable, but indicated that the difficulties of in execution have hampered the adoption of AI.

Research limitations/implications – The sample data were collected in Taiwan; therefore, the data may only represent the views of Taiwanese academic librarians on AI applications. The results of this study may not apply to librarians worldwide; however, they may provide a useful reference.

Practical implications – The results revealed the top four AI applications that libraries would most likely implement in the near future. Therefore, AI application developers and suppliers can prioritize the promotion of these products for to academic libraries. This study revealed that funding and costs related to AI implementation were discovered to be key factors relating to implementing AI applications. Some impediments to the implementation of AI applications relate to technological problems. Several librarians suggested that managers should invest more resources at an early stage rather than reducing cutting back on human resources initially. Although worries regarding privacy and ethics were mentioned expressed by some respondents, most academic librarians did not regard these to be major concerns.

Originality/value – This study provides the perspectives of librarians who have implemented AI applications and of those who have not. In addition, it explores the advantages and disadvantages of AI applications, and the level of support for and impact of AI applications and promotions. This study also included a gap analysis. Moreover, individual and organizational knowledge activity scales were adopted to examine AI awareness and the perceptions of academic librarians.

Keywords Academic libraries, University libraries, Artificial intelligence, Academic librarians, Knowledge activities, Knowledge management

Paper type Research paper

Introduction

Artificial intelligence (AI) is ubiquitous in modern life. AI and its related technologies are widely used, including by companies such as Apple, Google, Facebook, and Tesla. Several reports (Ransbotham *et al.*, 2017; Frank *et al.*, 2018) have indicated that AI has reshaped



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business and that intelligent automation processes might lead to the replacement of workers and job content substitutions. According to the [American Library Association \(2019\)](#) AI will become an indispensable tool for librarians, suggesting that the role of libraries will become more complex and future librarians may require higher-order critical, creative, and innovative thinking and emotional engagement.

[Coleman \(2018\)](#) noted that a library's AI program must be purpose driven rather than technology driven, including everyone in the discussion, planning, and implementation of AI to problem solve together. [Huang \(2020\)](#) examined several AI applications and advocacy programs for libraries, each with their own objectives, such as AI for Librarians (<https://www.aiforlibrarians.com/>), AI Lab (University of Rhode Island, <https://web.uri.edu/ai/>), HAMLET (MIT, <https://hamlet.andromedayelton.com/>), PAIR (University of Oklahoma, <https://pair.libraries.ou.edu/>), SUL AI Studio (Stanford University, <https://library.stanford.edu/projects/artificial-intelligence>), and The 99 AI Challenge (University of Toronto, <https://oneseach.library.utoronto.ca/ai-challenge>). "AI for librarians" (<https://www.aiforlibrarians.com/>) contains several examples of AI use and is the most useful AI guide for librarians. In this study, all possible applications of AI technology (e.g. machine learning approaches to pattern and face recognition, natural language processing, expert systems, speech production, machine vision, intelligent planning, and robotics) that can support research and teaching in universities were considered.

Some scholars have thus performed various AI-related library programs and projects, [Heck et al. \(2021\)](#) suggested two advantages of moving from information literacy to AI literacy. First, AI supports information literacy learning and teaching, indicating that AI systems might include methods that help learners gain problem-solving skills. Second, information literacy supports AI, indicating that AI requires user empowerment and the ability to self-manage; therefore, AI systems can facilitate the discovery of relevant personalized information.

Several studies have addressed the use of AI applications in libraries ([Mogali, 2014](#); [Tally, 2016](#); [Asemi and Asemi, 2018](#); [Vijayakumar and Sheshadri, 2019](#); [Oname and Alex-Nmecha, 2020](#); [Asemi et al., 2021](#); [Das and Islam, 2021](#)), and empirical studies have examined university and library environments and the awareness and perceptions of librarians with regard to AI ([Ex Libris, 2018](#); [Cox et al., 2019](#); [Wheatley and Hervieux, 2019](#); [Lund et al., 2020](#); [Abayomi et al., 2021](#)). Thus, an increasing body of evidence is indicating that AI adoption is crucial in libraries.

However, AI is an emerging technology, and the willingness to adopt AI applications in libraries might change as AI technology advances. The vision and mission of universities is to be pioneers in scientific innovations and provide an enabling and supportive environment for academics in different fields while promoting sustainable development. Academic libraries should play a key role in supporting research. Investigating the key factors for implementing AI applications in academic libraries and the associated impediments is therefore worthwhile. The more we understand AI implementation, the more effectively and efficiently we can promote AI applications in libraries.

Some libraries are eager to adopt new but insufficiently mature technologies, whereas others are hesitant to be the first to use a new technology. In addition, new technology can be counterproductive. Thus, this study primarily aimed to determine, from various perspectives, which factors are crucial to the successful implementation of AI applications in academic libraries. This study also performed gap analysis revealing that not all AI applications are suitable for all libraries. The results are helpful for librarians wishing to make a contingency plan when AI applications are implemented in their library.

The remaining sections proceed as follows. First, literature on the following are reviewed: the development of AI, the implementation of AI in universities and libraries, concerns relating to AI applications in libraries, empirical studies of AI applications in libraries,

knowledge activities, AI awareness, and perceptions of AI among academic librarians. Second, five research questions are proposed. Third, the questionnaire items and data collection methods are described. Fourth, the statistical analysis and results are presented. Finally, the conclusion, implications, limitations, and future research are discussed.

Literature review

Development of AI

The origins of AI can be traced back to Second World War, with [Turing's \(1947\)](#) lecture on the need to program computers rather than build machines. By the late 1950s, researchers were beginning to contribute to the development of AI ([McCarthy, 2007](#)). [McCarthy \(2007\)](#), a legendary computer scientist, defined AI as follows: "It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable. (p. 2)"

AI research has several branches. [Kulkarni \(2016\)](#) provides a graph describing AI typologies and the relationships between different branches, which include machine learning (ML), natural language, expert systems, speech, vision, planning, and robotics. Deep learning, a branch of ML, is currently a focus of research, providing algorithms that support the technological development of Google's self-driving car, face recognition, and SIRI.

Big data infrastructure has been developing since the 1990s and is leading to rapid developments in AI research, facilitating a new era of AI applications. [Tredinnick \(2017\)](#) noted that AI exists not only in movies and fiction but also in the workplace. A report by *MIT Sloan Management Review* and Boston Consulting Group revealed that AI is increasingly being adopted by numerous industries, including those related to technology, the media, telecommunications, customer services, financial services, professional services, and the health-care sector ([Ransbotham et al., 2017](#)). Apple, Google, Facebook, and Tesla have incorporated many AI and ML technologies into their products ([Kirkwood, 2018](#); [Griffey, 2019](#)). The cofounder of Coursera, Andrew Ng, stated that the role of AI is similar to that of electricity 100 years ago. AI is the new electricity and will transform products in different industries, such as those related to logistics, health care, security, and transportation ([Lynch, 2017](#)). [Ma et al. \(2020\)](#) explored the widespread use of AI applications in public services in China, including for smart traffic, intelligent information management, intelligent government services, and smart health care, and described the challenges resulting from a lack of key intelligent technologies and standard systems for their applications as well problems pertaining to relevant patents owned by IBM, Google, and Microsoft.

In this study, the author attempted to consider all possible applications of AI technology (e.g. ML approaches to pattern and face recognition, natural language processing, expert systems, speech production, machine vision, intelligent planning, and robotics) that can support research and teaching in universities. This study not only investigated the AI applications that can support academic library operations, but also explored the potential role of academic libraries in facilitating AI literacy and supporting AI incubation on the university campuses.

Implementation of AI in universities and libraries

AI applications are not only used in commercial products; scholars have advocated the adoption of AI for use in educational technology in higher education for developing digital learning, adaptive learning software, and research ([Becker et al., 2017](#)). [Luckin \(2016\)](#) suggested four manners in which AI can benefit universities: preparing students for the AI world, helping higher education institutions manage the large amounts of educational data,

supporting researchers to participate in the AI revolution, and conducting research on AI systems in universities. These four perspectives provide an overview of the future applications of AI on university campuses and indicate several approaches and action plans that must be developed. Furthermore, it is essential to explore the role of academic libraries in helping students achieve AI literacy.

Pinfield *et al.* (2017) proposed a report for the Society of College, National, and University Libraries to map the future of academic libraries, noting that some emerging technologies, such as AI and ML, appeared to be less well understood among academic librarians; therefore, improving their understanding of AI-related technologies is essential. Kirkwood (2018) stated that, through the application of AI technology, information professionals could explore data and resources in greater depth, create more innovative solutions, and provide greater value for users.

Some research has envisioned how AI applications could be applied to the library environment. Mogali (2014) described AI and its applications in libraries in relation to several activities, including expert system applications (reference services, acquisition, cataloging, classification, and the indexing of periodicals), natural language processing (searching databases and online public access catalogs), pattern recognition (symbolic ML, graph-based clustering, and classification), and robotics (e.g. a robotic on-demand batch-scanning system that would allow users to browse printed material through a web interface).

Furthermore, Vijayakumar and Sheshadri (2019) explored the possible applications of and Huang (2020) examined AI use in libraries in the United States, Canada, and Europe. Oname and Alex-Nmecha (2020) comprehensively reviewed papers concerning AI use in libraries; they covered various topics including the justification for applying AI in libraries, AI concepts and trends, and the numerous applications of AI in library and information services—such as for automatic cataloging and classification, automatic indexing using expert systems, smart engagement with online sources, and interactive bibliographic instruction. Das and Islam (2021) conducted a systematic literature review of 32 papers relating to the use of AI and ML in libraries and extracted nine themes of AI applications: including collection building and management, circulation and user services, reference services, library administration, library customization and retrieval. They also revealed that several ML techniques have been widely used for metadata generation, resource discovery, and book acquisition.

Because of the many review papers relating to AI applications in libraries, some researchers have proposed a taxonomy for describing AI applications in library systems. Asemi and Asemi (2018) employed exploratory factor analysis to identify the AI techniques that are most applicable in libraries; they identified four criteria: including expert systems, decision support systems and recommender systems, intelligent data mining systems, and natural language processing systems. Asemi *et al.* (2021) reviewed papers relating to AI technologies for libraries, revealing that intelligent systems were mostly designed to detect and replace books on the shelf and suggesting that librarian–robot interaction be improved. Furthermore, they classified the related research into four areas: technology, services, users, and resources. In short, emerging AI technologies can help libraries develop user-friendly, graphic, and seamless intelligent systems based on human–computer interactions.

Rather than reviewing all possible AI applications in libraries, Talley (2016) focused on the current use of intelligent agent technology and explored potential uses of complex AI applications to complement the reference work of librarians in academic law libraries. For example, an agent-based digital tutor system used in undergraduate education was developed to create a “student-centered, self-paced, and highly interactive” web-based asynchronous learning environment; this is one approach to incorporating agent technology into information literacy instruction. Another example is an agent-based virtual reference system that can answer a library patron’s questions with the results from previous reference

transactions. By answering patron questions, the system frees up librarians' time to focus on more sophisticated reference questions that require their expertise as well as on other more in-depth information services. This concept is consistent with the statement made by the library policy and advocacy blog of the International Federation of Library Associations: "A librarian . . . can provide a much better tailored service, potentially using up time freed up by using AI." ([International Federation of Library Associations, 2018](#)).

Figure 1 illustrates the relationships between various parts of the literature. According to the literature, AI can not only help librarians be more effective in four dimensions of their day-to-day work but also efficiently provide users the information that they need. At its present state of development, AI holds promise as a tool for library operations but this promise remains untested because AI has not been extensively implemented in libraries. Thus, the present study could only examine a few empirical studies and practical cases. Therefore, exploring the types of AI applications that academic libraries have implemented or expect to implement in the near future is worthwhile. In addition, the key factors affecting the success of AI application implementation in academic libraries, as well as impediments to implementation in libraries that are hesitant about AI applications, should be investigated.

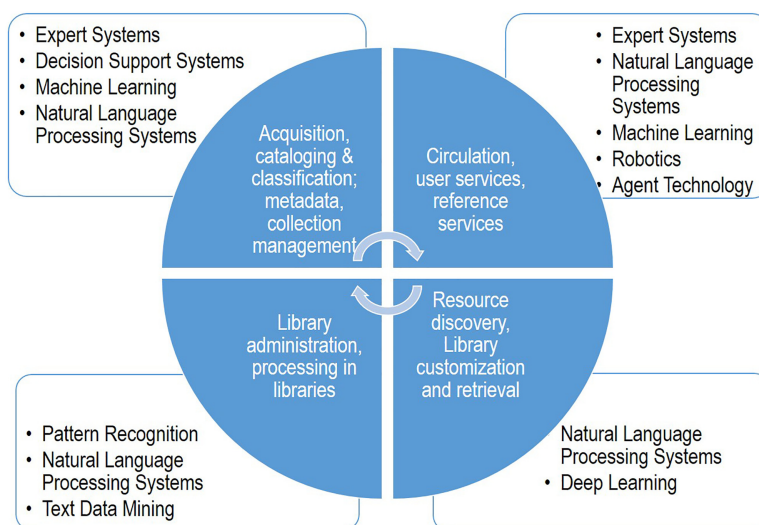


Figure 1.
Utility of AI in four
dimensions of library
operations

Concerns relating to AI applications in libraries

Most people consider the application of AI in libraries to be inevitable. However, some library and information science (LIS) researchers and practitioners are concerned about the potential risks. Tally (2016) stated that AI applications come with several of the following risks and drawbacks. First, the use of AI might lead to unemployment; second, the cost of AI is difficult to quantify; third, privacy and legal concerns remains; and lastly, it is difficult to ensure that AI agents can never offer legal advice. Thus, AI should be applied with caution. Johnson and Verdicchio (2017) noted that "AI anxiety" is caused by three main factors: "an exclusive focus on AI programs that leaves humans out of the picture, confusion about autonomy in computational entities and in humans, and an inaccurate conception of technological development. (p. 2267)" Moreover, the Ex Libris White Paper presented four major concerns

raised by librarians. First, librarians might be replaced by AI technology, resulting in job losses. Second, because of the efficiency of AI, human creativity and empathy might be lost from library services. Third, AI could amplify inequality, bias, and discrimination and lead to the dissemination of misinformation. Finally, the implications of AI on data privacy have raised ethical concerns (Ex Libris, 2018). Regarding the ethical concerns related to AI, Miao (2019) reviewed the literature on human right ethics in AI and proposed that AI researchers should incorporate the necessary ethical concepts into their programming when they develop AI products.

Oname and Alex-Nmecha (2020) reiterated several viewpoints expressed by Ex Libris (2018) and further indicated several challenges to implementing AI in libraries, such as a lack of technical knowledge, lack of adequate funding, high cost in developing and maintaining systems, the inherent complexity of AI systems, limited natural language capabilities, and a dearth of AI experts among library automation vendors. Oname and Alex-Nmecha stated, "The more intelligent the system is, the more that must be invested therein" (p. 137). However, AI in libraries is currently being affected by a lack of personnel with the skilled required to use expensive development tools.

Empirical studies of AI applications in libraries

Cox *et al.* (2019) interviewed 33 people, including library managers, library commentators, and nonlibrary participants, about their potential role in supporting and using AI and the potential uses of AI in libraries. Support roles include procuring AI content, conducting data quality control, curating derived data, designing data infrastructure to enable AI, explaining how to explore the new environment, and teaching critical data literacy. Suggestions were based on the function of library and extended library services in an AI environment.

In addition to qualitative research, several studies have used surveys to investigate the perceptions and attitudes of academic librarians toward AI in various countries. Wheatley and Hervieux (2019) evaluated 25 universities and their libraries in the United States and Canada, revealing that only 18.5% of academic libraries offered programming and services related to AI, indicating a lack of response to or awareness of the increasing use of AI. Lund *et al.* (2020) distributed their surveys through the International Federation of Library Associations' Information Technology and Academic and Research Libraries listservs and acquired 236 responses from academic librarians on their perceptions of AI. They then examined the alignment of these perceptions with the diffusion of innovations in adopter categories. Abayomi *et al.* (2021) adopted the questionnaire from the aforementioned study to investigate the awareness and perception of AI among 100 academic librarians in Nigeria.

Japan is a leader in robotics, particularly for everyday applications. Harada (2019) introduced various types of AI technology that have been implemented in several libraries in Japan, including a guiding humanoid robot called "Pepper;" the robot suit HAL (standing for hybrid assistive limb), which was developed to assist in lifting and reduce the burden on the waist with automatic book tracking; and the game "KOKORO Saver," which recommend books for children in accord with their interests and after analyzing what they post on social media.

Knowledge activities, AI awareness, and perception among academic librarians

Fernandez (2016) suggested that libraries should collaborate not only with each other but also with other industries to overcome institutional barriers, thus benefiting from economies of scale. In addition, AI should be deployed in a manner that is not only ethical and service oriented but also consonant with the venerable tradition of librarianship. Librarians should consider how AI would affect libraries and how they could optimize the use of AI technologies. An open-minded and creative library environment might help librarians make effective decisions in relation to the adoption and implementation of AI technologies.

Faced with rapid global, social, and technological changes, librarians have served as knowledge workers (White, 2003; Bennet, 2004) and social entrepreneurs (Allison, 2007). Librarians must not only be alert to the existing environment when preparing new knowledge products and services but also envision future knowledge needs (Bennet, 2004). Therefore, identifying the intangible work performed by librarians and discovering potential to transform the future creative form of academic library services are crucial.

Lund *et al.* (2020) adopted Roger's diffusion of innovation model to explore the perceptions of AI among academic librarians. The results demonstrated a strong relationship between librarians' perception of the knowledge of AI and adopter category. Huang (2014) proposed a knowledge activity scale for assessing individual tacit knowledge and organizational knowledge, indicating that the proposed measurement items could be used to measure the effect of the creative organizational climate; a higher score demonstrated a stronger innovative environment. In this study, this scale was adopted to explore the relationship between the awareness and perception of AI among academic librarians and knowledge activities. Knowledge activities are activities performed to acquire, externalize, and reuse relevant knowledge and activate the development of new knowledge to achieve certain goals (Lai and Lee, 2007). Huang (2014) defined knowledge activities from a comprehensive perspective and categorized knowledge activities into individual and organizational dimensions. Five positive constructs and three negative constructs were concluded to exist among individual knowledge activities; three factors pertaining to organizational knowledge activities were identified. In the present study, two constructs (knowledge absorption and knowledge sharing) from the dimension of individual knowledge activities and two factors (knowledge growth and knowledge integration) from the dimension of organizational knowledge activities were used to explore the relationship between AI awareness and perception in academic librarians.

Research has revealed that several types of AI application are used in libraries; however, although some libraries have already adopted AI applications, others have yet to do so. In addition, understanding the key factors and impediments related to the adoption of AI applications for libraries and identifying the gaps between the level of support for the different approaches to promoting AI and the likelihood of implementing them is essential. Therefore, the author proposed the following research questions:

- RQ1. What types of AI applications have academic libraries implemented or are expecting to implement in the near future?
- RQ2. What are the key factors for the successful implementation of AI applications in academic libraries? What are the differences, if any, between the libraries that have implemented AI and those that have not yet done so?
- RQ3. What are the impediments to promoting AI applications in academic libraries? What are the gaps, if any, between the level of support for AI and the negative effect on the library of the impediments?
- RQ4. Are individual and organizational knowledge activities related to the awareness and perception of AI among academic librarians?
- RQ5. What approaches have libraries taken to promote AI? What are the gaps, if any, between the level of support for these approaches and the chosen approaches in academic libraries?

Methodology

To perform a comprehensive search of the English-language and traditional-Chinese-language literature and to understand the state of the art of AI applications in libraries, the

keywords “artificial intelligence” and “libraries” (and their traditional Chinese counterparts) were used in searches on Google scholar and library-science-related databases without time span. The snowball method was employed, wherein the references cited in identified studies were also examined as candidates for inclusion. Almost 100 sources were examined in the literature review before the research questions of this study were proposed.

The study used quantitative research methods to explore the key factors and impediments relating to AI implementation among academic libraries in Taiwan.

According to the school directory compiled by the Ministry of Education in Taiwan, except for religious studies schools, Taiwan has 152 colleges and universities. The author scrutinized the library website of these institutions to identify librarians’ email addresses; however, many libraries do not provide this information on their websites for each librarian. Nevertheless, the author obtained the email addresses of 1,622 librarians, who served as this study’s sample. After encouraging librarians to respond to our questionnaires, the author received 472 valid questionnaires, a 29.1% response rate.

Survey questionnaire items were related to individual and organizational knowledge activities, librarians’ perception of and attitude toward AI applications in library work settings and the current status of AI implementation, and the level of support for and likelihood of implementing different approaches to promoting AI applications in libraries. To improve the content validity of the questionnaire, the author held a preliminary interview with two experts who were familiar with the implementation of intelligent libraries; one expert had experience as a consultant, and the other had experience as a vendor. [Table 1](#) summarizes the questionnaire items, which are detailed in the Appendix ([Tables A1–A3](#)). Both open and closed questions were included in the sections on AI applications and their implementation. A 5-point Likert scale was adopted for the closed questions. Regarding the scale reliability of these questionnaire items measuring knowledge activities, the typical approach to reliability assessment is the Cronbach’s α , which ranges from 0 to 1. As shown in [Table A3](#) in [Appendix](#), all Cronbach’s α values were higher than 0.7, which was acceptable for capturing the dimensions ([Nunnally, 1978](#)).

Table 1.
Sources of
questionnaire items

Questionnaire items	Reference sources
Individual and organizational knowledge activities (14 questions)	Huang (2014)
Perception of and attitude toward AI applications in library work settings and the current status of AI implementation (25 questions)	Wheatley and Hervieux (2019) , Ex Libris (2018)
Level of support for and likelihood of implementing approaches to promoting AI applications in libraries (13 questions)	Huang (2020)

Data analysis and findings

The demographic profile of the 472 respondents is presented in [Table 2](#). Approximately 75% of the respondents were women and more than 80% were aged between 31 and 60 years. Approximately 70% of the respondents had majored in LIS, and the non-LIS respondents had majored predominantly in computer science, the arts and humanities, management, science and technology, and the social sciences. Approximately 10% of the respondents held a doctoral degree and approximately 30% were managers, directors, or deans of the library. The average total number of working years as an academic librarian was 18.43, and the average number of working years in their current job was 12.42; job duties included access services, cataloging and acquisition, consultation services, electronic resources management, journal management and interlibrary loans, circulation and collection management, library systems and website management, scholarship and research support services, digital learning services, and general administration.

Table 2.
Demographic profile of
respondents

Gender	Major		Major		
	<i>n</i>	%		<i>n</i>	%
Women	353	74.8	Library and Information Science (LIS)	324	68.6
Men	119	25.2	Non-LIS	148	31.4
Age	Educational background				
	<i>n</i>	%		<i>n</i>	%
≤30	45	9.5	High school	3	0.6
31–40	125	26.5	Bachelor's degree	196	41.5
41–50	158	33.5	Master's degree	225	47.7
51–60	129	27.3	Doctoral degree	48	10.2
≥61	15	3.2			

Table 3 provides a profile of the 472 librarians who responded to the questionnaire. They were employed at libraries with <5 staff to >101 staff; 60% of the respondents were from small libraries with fewer than 20 staff.

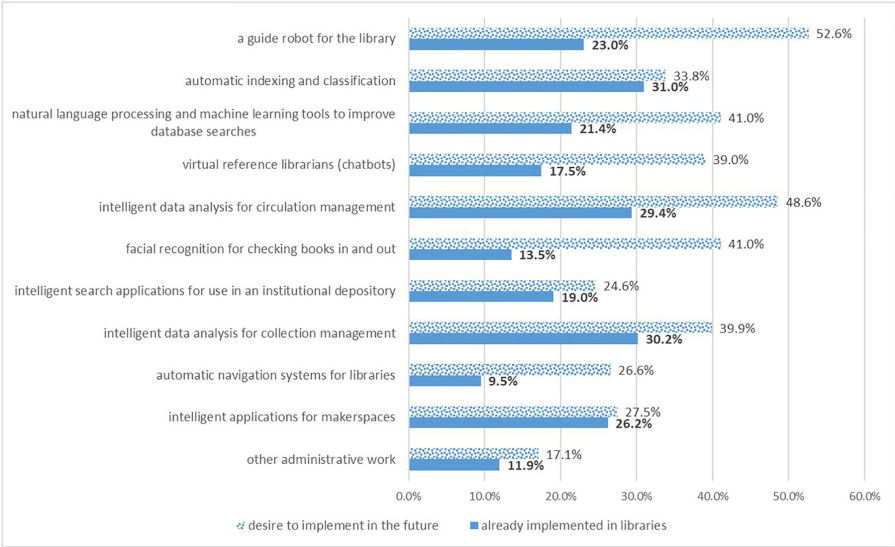
Table 3.
Library scale (number
of staff)

Staff	<i>n</i>	%
≤5	52	11.0
6–10	89	18.9
11–20	144	30.5
21–30	76	16.1
31–40	30	6.4
41–50	13	2.8
51–60	11	2.3
61–70	13	2.8
71–80	13	2.8
81–90	8	1.7
91–100	5	1.1
≥101	18	3.8

Implementation of AI applications and staff expectations in academic libraries

A total of 126 respondents replied that their libraries had already adopted AI applications, indicating that 26.7% of academic librarians had implemented AI applications in their libraries. [Figure 2](#) summarizes the AI applications that academic libraries had already implemented and those that libraries had not yet implemented but aimed to implement in the future. The list of AI applications was presented in a multiple-choice format, and the percentage was calculated by total score for each item divided by the number of respondents in the two study groups ($n = 126$, $n = 346$). The top three AI applications implemented in academic libraries relate to automatic indexing and classification, intelligent analysis for collection management, and intelligent analysis for circulation management. More than 40% of respondents replied that they would like to implement the following AI applications in the future: a guide robot for the library (52.6%), intelligent analysis for circulation management (48.6%), natural language processing and ML tools to improve database searches (41%), and face recognition for checking books in and out (41%). Our results differ from those of [Abayomi et al. \(2021\)](#), who presented the following list ranked in order of AI adoption:

Figure 2.
AI applications
(already implemented/
desire to implement in
the future) in academic
libraries



Key factors for the implementation of AI applications in academic libraries

The key factors relating to the implementation of AI applications in academic libraries are listed in Table 4. Not all respondents provided specific comments for this item. A total of 32 librarians whose libraries had already implemented AI applications and 149 librarians whose libraries had not yet implemented AI applications provided comments. These comments were coded according to the multiple choice options, and the final 13 categories are presented in Table 4. The highest percentage (25 and 40%) of the librarians regarded cost of AI implementation and available funding as key factors. People-related factors, including human resources, librarians' willingness and experience, support from managers, and the support and planning of universities, formed a large percentage of the key factors. Factors relating to the ability of AI applications to save labor, time, and energy accounted for almost one-fifth of librarians' comments. Approximately, 15% of librarians whose libraries had already implemented AI indicated information security and privacy concerns as key factors; however, only a few librarians whose libraries had not yet implemented AI mentioned these factors.

Impediments to promoting AI applications in academic libraries

The author collected quantitative data to examine the impediments to promoting or implementing AI applications in academic libraries. The quantitative data were derived from seven questions with negative statements using a 5-point Likert scale "(from 1 = *strongly disagree* to 5 = *strongly agree*)". Respondents indicated the extent of their agreement with each statement, and the results are summarized in Table 5. The top three responses were a lack of financial resources, technological resources, and human resources. The lowest level of agreement related to the statement that "Librarians are concerned about job losses as a result

Key factors	Libraries that have already implemented AI (<i>n</i> = 32)		Libraries that have not yet implemented AI (<i>n</i> = 149)	
	<i>n</i>	%	<i>n</i>	%
Funding/cost associated with implementation	8	25	59	40
Human resources	4	13	23	15
Librarians' willingness and experience	3	9	18	12
Support from managers	1	3	21	14
Support and planning of universities	2	6	4	3
Labor/time/energy saving	6	19	28	19
Maturity and reliability of AI applications	3	9	21	14
Acceptance by users (attractiveness, function, convenience)	3	9	12	8
Innovative services/alignment with technological trends	2	6	10	7
Increasing library visitors and use	2	6	12	8
Incorporating library core values	1	3	2	1
Managerial concerns*	3	9	5	3
Information security/privacy concerns	5	15	2	1

Note(s): *Those whose library had implemented AI commented on low usage and ineffective outcomes. Those whose library had not yet implemented AI commented on the effectiveness of problem solving, not having to manage workers' emotional problems, and the simplification of tasks

Table 4.
Key factors in the
implementation of AI
applications in libraries

of being replaced by AI," indicating that librarians considered that they would not be replaced by AI. These results are consistent with those of [Lund *et al.* \(2020\)](#) but not with those of [Abayomi *et al.* \(2021\)](#), which suggested that the fear of job losses was the major constraint to the adoption of new technologies by academic librarians in Nigeria.

Furthermore, the author asked respondents to indicate the extent to which the situation described in each item impeded the promotion of AI (1 = *not at all important* to 5 = *extremely important*). This study conducted a Wilcoxon signed-rank test with the two related samples procedure to determine the associations between the level of agreement with the statements and the degree to which certain factors impeded the promotion of AI ([Table 5](#)). Technological, financial, and human resources were the three main impediments, indicating that these factors have a significant negative impact on the promotion of AI. By contrast, the level of agreement with the statements on AI magnifying injustices and endangering data privacy was significantly higher than the degree that these matters impeded AI promotion, indicating that librarians do not consider these factors to be major impediments to the implementation of AI applications in libraries.

The qualitative data were derived from the open questions in the questionnaire. The responses to open questions were coded and categories were formed. The open responses from 26 librarians whose libraries had implemented AI are presented in [Table 6](#); those from the 129 librarians whose libraries had not yet implemented AI are presented in [Table 7](#). More than 50% of librarians mentioned funding and cost of AI implementation as the main impediments to the implementation of AI applications because well-developed AI products and their maintenance costs are expensive. For librarians whose libraries had already implemented AI applications, human resources and technological problems were the next largest concern because not all librarians have strong AI literacy and AI products are not necessarily user friendly, resulting in unexpected problems after implementation. The third major impediment is managerial problems, such as an increase in conflict because the AI product is unreliable and senior managers having high expectations of the effectiveness of the AI applications.

Table 5.

Difference between the level of agreement with statements and the perception regarding the extent that these matters would impede AI implementation in libraries ($N = 472$)

Items	Level of agreement		Level of impediment to implementing AI		Z
	Mean	SD	Mean	SD	
Lack of human resources to promote AI in libraries	4.00	0.810	4.10	0.913	−2.83**
Lack of technological resources to promote AI in libraries	4.05	0.836	4.21	0.858	−4.73***
Lack of financial resources to promote AI in libraries	4.22	0.910	4.36	0.870	−3.80***
Librarians are concerned about job losses as a result of being replaced by AI	2.74	0.890	2.85	1.001	−2.97**
The library's connection to its community and human characteristics will be devalued because of AI efficiency	2.92	0.912	2.89	0.979	0.75
AI would magnify injustices, such as inequality, bias, and discrimination, and help propagate misinformation	3.14	0.818	3.05	0.933	2.58*
AI endangers data privacy, and privacy is vital in libraries	3.35	0.800	3.25	0.932	3.41**

Note(s): * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 6.

Open responses regarding the impediments to the promotion of AI applications from librarians whose libraries have implemented AI applications ($n = 26$)

Items	n	%
Funding and cost associated with implementation	14	54
Human resources	6	23
Technological problems (technical capability of the suppliers and their product, ineffective responses to questions, immature product, equipment maintenance)	6	23
Managerial problems (replacing existing service resources, misunderstandings because of unreliable technology, increased conflict, limited help in the library, few administrative resources)	5	19
Willingness and acceptance among librarians	3	12
Support from the university	3	12
Privacy concerns	3	12
Library stereotypes from the readers/difficult to promote innovative services	1	4

For librarians whose libraries had not yet implemented AI applications, in addition to funding and costs associated with AI implementation, the main impediments were the awareness and willingness of librarians and related human resource problems. These librarians were concerned about the lack of human resources to support the new services. In addition, they were concerned about the maturity and reliability of AI applications. If these applications are unreliable, more time may be required to address the problem, leading to more managerial problems (Table 7). In short, many librarians are averse to change; they are worried about uncertainty and resist the adoption of new services.

Relationship between individual and organizational knowledge activities and the AI awareness and perceptions of academic librarians

This study explored the relationship between individual and organizational knowledge activities and the awareness and perceptions of AI among academic librarians. The Pearson's correlation coefficients for the six items the author employed are presented in Table 8. The mean and standard deviation of the questionnaire items relating to AI awareness and perception and individual and organizational knowledge activities are listed in Appendix. According to the results, no relationship was detected between two items (perception about AI, jobs might be replaced by AI) and organizational knowledge activities. Almost all the

positive items relating to AI awareness and perception were significantly positively correlated with individual and organizational knowledge activities. The more individual and organizational knowledge activities the librarians and libraries held, the more positive the attitude was toward AI applications in their libraries.

The
implementation
of AI in
libraries

Items	<i>n</i>	%
Funding and cost associated with AI implementation	69	53
Awareness, acceptance, and willingness of librarians/librarians lack of understanding of AI applications	32	25
Human resources	25	19
Maturity and reliability of AI application/equipment maintenance problems	23	18
Support from managers and universities	15	12
Managerial problems (investing more resources rather than reducing human resources in the short term, investing more money, no urgent necessity, unclear effectiveness, librarians must provide more detailed services than existing robots, increase in business, lack of communication on the promotion of AI)	13	10
Technological environment of the library is insufficient for effective AI services	9	7
Privacy concerns	8	6
Library stereotypes from readers/difficult to promote innovative services	4	3

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Table 7.
Open responses
regarding the
impediments of AI
implementation from
librarians whose
libraries have not yet
implemented AI
applications (*n* = 129)

Items	Knowledge absorption	Knowledge sharing	Knowledge growth	Knowledge integration
You have a good understanding of the concept of AI	0.058	−0.003	−0.034	−0.025
AI has a positive effect on your life	0.233**	0.144**	0.168**	0.127**
AI has a positive effect on your work	0.255**	0.181**	0.247**	0.254**
Your job might be replaced by AI in the future	0.018	−0.048	0.032	0.063
The implementation of AI could improve some work functions in your library	0.262**	0.193**	0.254**	0.261**
Users will be interested in AI applications in your library	0.270**	0.199**	0.264**	0.305**

Note(s): ***p* < 0.01

Table 8.
Correlation coefficients
for organizational
knowledge activities
and AI awareness of
academic librarians

Difference between support and approaches to the promotion of AI applications in academic libraries

Librarians were provided with six approaches that libraries can employ to promote AI; librarians responded by stating their agreement with each of the statements and the likelihood of the implementation of each approach (Table 9); the respondents' agreement with the statements was considered an indication of their support for the approach. The item regarding promoting AI literacy among users and librarians received the most support from the librarians. The least support was noted for the following approaches to AI integration: libraries could provide both tangible and intangible laboratories for interdisciplinary AI-related research projects, libraries could act as an AI repository, and libraries could host AI competitions. The Wilcoxon signed-rank test with the two related samples procedure was performed to determine the association between the level of support and likelihood of implementation of the six approaches. The results revealed that

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five items had a significant level of support but had a lower likelihood of being implemented, indicating that most librarians do not believe they can play a key role in the AI world.

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Items	Support		Likelihood of implementation		Z
	Mean	SD	Mean	SD	
Librarians could educate people on AI and help to promote AI literacy	3.97	0.701	3.91	0.814	2.09*
AI-related activities and competitions could be held by the library	3.55	0.858	3.50	0.926	1.89
Librarians could discuss AI applications to facilitate an understanding of AI	3.89	0.710	3.81	0.837	2.75**
Libraries could conduct AI-related research projects and become an AI research repository	3.55	0.846	3.45	0.978	3.13**
Libraries could be the focus of interdisciplinary activities, providing tangible and intangible classrooms for interdisciplinary AI-related courses on campus	3.75	0.751	3.57	0.931	6.09***
Libraries could be the focus of interdisciplinary activities, providing tangible and intangible laboratories for interdisciplinary AI-related research projects, becoming an incubator on campus	3.54	0.880	3.40	0.994	4.60***

Table 9.
Level of agreement with approaches to promoting AI in academic libraries and the likelihood of implementing said approaches (N = 472)

Note(s): *p < 0.05; **p < 0.01; ***p < 0.001

Discussion and implications

AI is akin to electricity in our modern life, and it will transform services and products in different sectors (Lynch, 2017). Ransbotham *et al.* (2017) also noted that AI applications are being adopted in many industries. Librarians should consider how to apply AI in libraries to promote the efficiency and effectiveness of information organization as well as the quantity and quality of information services. Machines can identify patterns in and classify images, text, and audio much faster and more efficiently than humans can. Several conceptual studies have been conducted on AI applications in libraries (e.g. Mogali, 2014; Tally, 2016; Asemi and Asemi, 2018; Vijayakumar and Sheshadri, 2019; Oname and Alex-Nmecha, 2020; Asemi *et al.*, 2021; Das and Islam, 2021) and empirical studies examining librarians’ perceptions of AI (Ex Libris, 2018; Cox *et al.*, 2019; Wheatley and Hervieux, 2019; Lund *et al.*, 2020; Abayomi *et al.*, 2021). Although some studies have raised concerns about privacy and ethics in relation to AI (Tally, 2016; Johnson and Verdicchio, 2017; Ex Libris, 2018; Miao, 2019) and some challenges were noted by Oname and Alex-Nmecha (2020), the adoption of AI technology in library environments is inevitable. Therefore, the aim of this study was to explore the implementation of AI in academic libraries. The research results are summarized as follows.

First, the results demonstrated that the three AI applications most commonly already implemented in academic libraries are for (1) automatic indexing and classification, (2) intelligent data analysis for collection management, and (3) intelligent data for circulation management. According to the results, the four AI applications that libraries would most like to implement in the near future were guide robots for libraries, intelligent analysis for

circulation management, natural language processing and ML tools to improve database searches, and face recognition technology for checking books in and out. Studies (Mogali, 2014; Oname and Alex-Nmecha, 2020; Das and Islam, 2021) have also indicated the promise of these AI applications for libraries.

Second, this study considered key factors based on the views of librarians in libraries that have or have not implemented AI applications. The key factors relating to the implementation of AI applications in academic libraries included the cost of AI implementation and available funding; people-related factors; the ability of AI applications to save labor, time and energy; and acceptance by users. Some of these factors are consistent with the findings of Oname and Alex-Nmecha (2020), who reported several challenges in implementing AI in libraries. Moreover, some librarians whose libraries had already implemented AI applications indicated that information security and privacy concerns are key factors, consistent with the findings of other studies (Tally, 2016; Ex Libris, 2018; Miao, 2019); however, only a few librarians whose libraries had not yet implemented AI applications mentioned these factors.

Third, this study investigated impediments to promoting AI applications and identified the gaps between the level of support for AI and the negative effect of impediments. The three most common responses regarding impediments to promoting AI applications in academic libraries were a lack of financial, technological, and human resources. The gap analysis indicated that these three impediments significantly hampered the implementation of AI. This is consistent with the findings of Oname and Alex-Nmecha (2020), who reported that lack of AI experts in libraries and the high cost of development make AI challenging to implement in libraries. However, the levels of agreement with the statements that AI magnifies injustices and threatens data privacy were significantly higher than the levels of agreement with the statements that these matters impeded the promotion of AI, showing that librarians do not regard these factors to be major impediments to the implementation of AI applications in libraries. The results also revealed that librarians do not think that they will be replaced by AI. Therefore, the main impediments to the promotion of AI applications in academic libraries do not originate from the fear of job losses but from the other factors mentioned. Although studies have indicated that AI leads to unemployment (Tally, 2016; Ex Libris, 2018; Abayomi *et al.*, 2021), this study discovered that the fear of job loss is not a major concern for academic librarians.

Fourth, this study explored the relationship between individual and organizational knowledge activities and AI awareness and perception among academic librarians. The positive items relating to AI awareness and perception were significantly and positively correlated with individual and organizational knowledge activities except for two (perception of AI and job being replaced by AI). A higher score for individual and organizational knowledge activities indicated a more innovative environment (Huang, 2014). This is consistent with the findings of Lund *et al.* (2020), who revealed that librarians who were more likely to adopt emerging technology tended to be more optimistic about AI applications in libraries.

Fifth, the author proposed six approaches that libraries can employ to promote AI. Librarians responded by stating how much they would support each approach, thus indicating the likelihood of the implementation of each approach. The approaches that received support from the librarians could be ranked as follows: promoting AI literacy to facilitate an understanding of AI, providing tangible and intangible classrooms for interdisciplinary AI-related courses, conducting AI-research projects, having libraries act as an AI research repository and hosting AI competitions, and providing tangible and intangible laboratories for interdisciplinary AI-related research projects. A gap was identified between the level of support for the different approaches to AI promotion and the likelihood of implementing these approaches. Five out of six approaches had a significant level of support but a low likelihood of being implemented, implying that most of the librarians did not believe they could play a leading role regarding the promotion of AI applications on campus. This is

consistent with the findings of [Wheatley and Hervieux \(2019\)](#), who concluded that AI barely existed in academic libraries. Although some recent papers have reviewed possible AI applications in libraries ([Oname and Alex-Nmecha, 2020](#); [Das and Islam, 2021](#)), only a few studies have documented empirical cases of AI applications in libraries, such as the robot noted by [Harada \(2019\)](#), and “AI for Librarians” (<https://www.aiforlibrarians.com/>). However, as AI technology becomes more sophisticated, users may begin to have higher expectations of information services in libraries; therefore, the use of AI in information services and library operations will quickly become a necessity.

Practical implications

The results reveal the four AI applications that libraries would most like to implement in the near future. Therefore, AI application developers and suppliers may prioritize these products for academic libraries.

This study revealed that funding and costs related to AI implementation were key factors for implementing AI applications. The author suggests that librarians host fundraising events or collaborate with companies to overcome institutional barriers ([Fernandez, 2016](#)). Librarians must step into the unknown if they desire to make optimal use of AI at the right time to provide users with high-quality information services.

Some impediments to the implementation of AI applications relate to technological problems. The author suggests that the developers or suppliers of AI applications conduct more troubleshooting tests before installing AI applications in libraries. In addition, librarians should be aware of the capabilities of AI applications and consider how to combine these capabilities with library work instead of expecting AI to deliver more than it can.

Some librarians suggested that managers should invest more resources at an early stage rather than reducing human resources initially. This is similar to the S curve of learning when people experience a new task: the learner initially experiences a period of slow progress, followed by accelerated learning as the learner discovers new techniques, and then achieves a sense of proficiency. Therefore, librarians must be patient when implementing AI applications to allow sufficient time for the integration of the application into the library environment. However, the author recognizes that senior managers require rapid results given the considerable financial investment.

Although privacy and ethics were mentioned by some respondents, most academic librarians did not regard these as major concerns. However, these factors must still be considered when implementing AI applications in libraries.

Theoretical implications

This study applied an individual and organizational knowledge activity scale to examine librarians’ perceptions toward and awareness of AI. The results are consistent with those of [Lund et al. \(2020\)](#), who revealed that librarians were optimistic about the possibilities of AI. This scale was validated by a concurrent validity test using a creative organizational climate inventory ([Huang, 2014](#)). The author not only examined librarians’ individual knowledge activities but also investigated the libraries’ organizational knowledge activities, with the results indicating that both personal attitudes toward innovation and organizational climate might influence librarians’ perceptions toward AI adoption. Therefore, the knowledge activity scale could be a tool to measure librarians’ innovativeness, which might provide indicators for examining how AI applications could be implemented successfully in libraries.

Although some studies have highlighted librarians’ concerns regarding job security in the face of widespread AI adoption, in this study, academic librarians did not consider this to be a major concern. Financial, technological, and human resources, as well as data privacy, are considered to be of greater concern.

In this study, the author identified a clear gap between perceptions and actions; that is, librarians recognize that AI applications are inevitable, but the difficulties of execution hamper the adoption of AI.

Limitations and future work

The sample data were collected in Taiwan; therefore, the data may only represent the views of Taiwanese academic librarians on AI applications. The results of this study may not apply to librarians worldwide; however, they may provide a useful reference. Future studies might expand the scope of the sample data internationally. Furthermore, conducting a qualitative interview with librarians who have successfully implemented AI applications may provide more detailed information on the use of AI applications in academic libraries.

Conclusions

Academic librarians are eager to have up-to-date technology and provide users with the most efficient and effective information services. The author noted the passion of some academic librarians while conducting the survey; they not only responded to the survey immediately but also provided a valuable contribution to the research and requested the study results. They would like to use the research results as a reference for adopting AI applications.

The value of this study is that it provides two perspectives – from those who have implemented AI applications and those who have not. The study also presents the advantages and disadvantages of AI applications, and the level of support for AI applications and promotion and impediments to implementation. Therefore, a gap analysis was included in this study. In addition, both individual and organizational knowledge activity scales were adopted to examine the awareness and perception of AI among academic librarians, with results that are consistent with those of [Lund et al. \(2020\)](#).

Human resources are vital for facilitating future challenging work. [Cox et al. \(2019\)](#) proposed several potential library roles for AI, and [Heck et al. \(2021\)](#) presented two perspectives of AI literacy. These two studies provide valuable insights that could support the design of a learning model for librarians for on-the-job training and promote individual and organizational knowledge activities in libraries.

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Table A1.
The questionnaire
items relating to AI
awareness and
perception

Appendix

Questionnaire items	Mean	SD
How well do you understand the concept of AI?	4.44	0.995
AI has a positive effect on your life.	3.58	0.640
AI has a positive effect on your work	3.50	0.658
Your job might be replaced by AI in the future.	2.92	0.945
The implementation of AI could improve some work in your library.	3.76	0.668
Users will be interested in AI applications in your library.	3.52	0.668
I often use AI technology in everyday life. [frequency question]		
Please list the AI applications in everyday life. [open-ended questions]		
I often use digital assistant in my everyday life. [frequency question]		
Please list the digital assistant in everyday life. [open-ended questions]		
Which of the following AI applications that you have adopted in your library? [yes/no questions]		
• guide robot for the library		
• automatic indexing and classification		
• natural language processing and machine learning tools to improve database searches		
• virtual reference librarians (chatbots)		
• intelligent data analysis for circulation management		
• facial recognition for checking books in and out		
• intelligent search applications for use in an institutional depository		
• intelligent data analysis for collection management		
• automatic navigation systems for libraries		
• intelligent applications for makerspaces		
• other administrative work		
• others [open-ended questions]		
What are the key factors for the implementation of AI applications in academic libraries? [open-ended questions]		
What are the impediments to promoting AI applications in academic libraries? [open-ended questions]		

Table A2.
Level of support for
and likelihood of
implementing
approaches to
promoting AI
applications in libraries

Questionnaire items
Lack of human resources to promote AI in libraries
Lack of technological resources to promote AI in libraries
Lack of financial resources to promote AI in libraries
Librarians are concerned about job losses as a result of being replaced by AI
The library's connection to its community and human characteristics will be devalued because of AI efficiency
AI would magnify injustices, such as inequality, bias, and discrimination, and help propagate misinformation
AI endangers data privacy, and privacy is vital in libraries
Librarians could educate people on AI and help to promote AI literacy
AI-related activities and competitions could be held by the library
Librarians could discuss AI applications to facilitate an understanding of AI
Libraries could conduct AI-related research projects and become an AI research repository
Libraries could be the focus of interdisciplinary activities, providing tangible and intangible classrooms for interdisciplinary AI-related courses on campus
Libraries could be the focus of interdisciplinary activities, providing tangible and intangible laboratories for interdisciplinary AI-related research projects, becoming an incubator on campus

Table A3.
The questionnaire
items relating to
individual and
organizational
knowledge activities

Construct	Questionnaire items	Mean	SD	Reliability coefficient
Knowledge absorption	My creativity comes from different professional sources	4.15	0.698	0.794
	I notice different cultures in my work environment	4.27	0.575	
	I listen to and observe changes that take place during work	4.34	0.564	
	I try to understand the opinions of different professionals	4.36	0.534	
Knowledge sharing	I seek advice from colleagues while working	4.42	0.570	0.874
	Once I have an idea, I share my idea with my colleagues	4.23	0.639	
	I gain ideas by brainstorming with my colleagues	4.25	0.645	
	I take time to share work-in-progress with colleagues	4.15	0.698	
Knowledge growth	Our education and training programs help raise knowledge levels among our employees	3.58	0.888	0.787
	We encourage staff to pursue their ambitions through learning and further study in our library	3.96	0.835	
	We incorporate knowledge from other domains to provide new services in our library	3.68	0.806	
Knowledge integration	We synthesize different opinions to propose new methods in our library	3.74	0.789	0.888
	We apply new methods to solve problems in our library	3.76	0.767	
	All staff have made considerable progress in the last 2 years	3.56	0.827	

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