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Library Knowledge Service Functional Areas from the Perspective of Future Learning Centers

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Abstract: As educational technology progresses, libraries as traditional places of learning support and knowledge acquisition are slowly changing to central places of collaborative learning and knowledge co-construction. Nevertheless, the contemporary way of learning is not the old fashioned passive assimilation but, using a range of technologies and tools, learner oriented methodology which adds to the experience and the level of engagement in the process of reading and learning. VR, big data technology and functional area configurations can be used to optimize the knowledge service functions of libraries to enhance the functionality of the library in terms of knowledge dissemination. This paper examines the ways to improve interactive communication and knowledge building skills in students with the help of hierarchical structure, flexible time organization and effective equipment arrangement of the library group discussion rooms at universities (portable whiteboards and multiple screen sharing system). In this paper, library knowledge service functional areas are systematically developed based on the future learning center perspective on three aspects, including: learner centered, deep integration of technology, and synergy between resources and activities. It suggests the implementation of metaverse technology VR/AR and data twins to achieve virtual environments and remote knowledge engines. Individualized schedules are set up representing various students, and learning centers are organized communally to facilitate communication between students and discussion of tasks. The findings of the research have shown that the design and organization of the collaborative learning environment are instrumental in stimulating critical thinking, effective conversation, and collaboration among students particularly in the intensification of a group creativity and efficiency in knowledge generation.

1. Introduction

As the application of AI technology in education is made, the areas of the knowledge service of libraries are also streamlined, and the traditional libraries knowledge passively learnt change to knowledge sharing and social interaction among learners. The collaborative learning areas have been identified as one of the most prominent hubs in the development of library learning support

space in this transformation.

In the paper, the design and management strategies of collaborative learning areas in the university libraries can be examined, with a special emphasis on how they facilitate interaction, knowledge building, and creative thinking in the learners with the help of hierarchical designing of group discussion rooms, equipments, and collaborative learning aids. Through a pilot verification in a university library, this study hopes to provide theoretical basis and practical guidance for the construction of future learning centers, while also offering innovative solutions for libraries to better support learners' personalized learning and teamwork.

2. Related Works

To better understand the application of artificial intelligence in library services and the challenges it faces, the following literature review explores relevant research findings, focusing on the potential and limitations of machine learning, natural language processing, recommender systems, and ChatGPT-based technologies in improving information retrieval efficiency, user experience, and work productivity.

Ikwuanusi et al. believed that by using machine learning, natural language processing and recommendation systems, personalized resource push, semantic search, real-time translation and virtual assistant support can be achieved, thereby improving user engagement and knowledge acquisition efficiency [1]. Barsha and Munshi reviewed the application prospects and challenges of artificial intelligence in library services in developing countries. AI can improve information acquisition efficiency, user experience and work productivity [2]. Lund et al. found that ChatGPT can assist users in obtaining library medical information, answering queries, providing recommendations and facilitating resource access, but there are still potential challenges and ethical issues in its application [3]. Subaveerapandiyan et al. conducted a questionnaire survey of 245 randomly selected library and information science professionals in Zambia. Library and information science professionals have a positive and optimistic attitude towards artificial intelligence, but they are also worried that artificial intelligence can replace the role of librarians [4]. Adigun et al. pointed out that although smart libraries provide great convenience for knowledge services, there are still bottlenecks in data privacy, digital inclusion, resource allocation, intellectual property and sustainability [5]. Huang focused on the key factors and obstacles to the use of various Artificial Intelligence (AI) tools in academic libraries. He found a gap between the level of support librarians have for AI applications and the negative impact of barriers [6]. Panda and Kaur analyzed the outcomes of implementing a chatbot system based on ChatGPT, as opposed to a conventional knowledge base chatbot system, in the Library and Information Center (LIC). They discovered that ChatGPT can potentially be more accurate and customized to user queries, provide a better user experience, and lessen the burden of library employees [7]. Following an interpretive research design, with sequential aspects, and a pragmatic paradigm, Dube and Jacobs did research, discussing the experience of participants and respondents with the expansion of library services to assist users with the COVID-19 pandemic. The findings indicated that the library of universities offered considerable assistance to distance education throughout the pandemic, including BOTsa (a chatbot that assists users to find the answers to their questions about the library quickly) [8]. To investigate the effects of artificial intelligence and ChatGPT on the library information services, Yang typed 22 reference questions inquiry questions to ChatGPT and assessed the quality and accuracy of its responses. The findings indicated that ChatGPT was effective in the information retrieval process in certain domains, whereas it failed to compete with the reference librarians in other domains [9]. Jha used content analysis techniques to conduct an extensive review of literature related to “artificial intelligence” and “smart library” to identify emerging technologies in the field

of smart library. The results of this study indicate that artificial intelligence is a dynamic technology that can be applied to library services [10]. Ferrara used a general qualitative approach to examine how library staff understand disability and attitude barriers. Participants were aware of attitude barriers, but they rarely considered these barriers when planning and implementing library projects and services [11]. Existing research mainly focuses on the application prospects and functional realization of artificial intelligence technology, but there are still significant bottlenecks in its actual application, especially in terms of ethical issues, technological challenges and the substitutive impact on the role of librarians in library services.

3. Methods

3.1 Overall Design Concept of Functional Areas

3.1.1 Learner-Centered Learning Experience Orientation

The construction of knowledge service functional areas in libraries should respond to the trend of university libraries shifting their spatial functions from "collection storage" to "learning support." With increasing pressure on physical space, the traditional space model primarily focused on storing documents can no longer meet the growing demand from readers for a combination of information, technology, knowledge, and skills. Libraries increasingly need to provide readers with learning environments for discussion, research, practice, and innovation through spatial redesign and technological integration. Therefore, functional area planning should be designed holistically from three dimensions: "learner-centered," "deep integration of technology," and "systematized resource-activity collaboration," to form a dynamic learning ecosystem that supports diverse learning methods.

In this regard, libraries have ceased being a stagnant collection of paper records, they are learning environments, centres of academic interaction, and innovational engines. The approach to functional area design as a learner-centered approach should enable students to have freedom in space utilization as well as to build their own learning path. As an illustration, it suits the requirements of different situations like focused reading, in-depth writing, immersive retrieval, group discussion, and relaxation to reflect by offering different seating areas, moveable partitions, adjustable lighting, and acoustic comfort design. At the same time, the fact that the learning process is perceptible and can be modified is also crucial. By using behavioral clues, collaborative tool environment, and guidance mechanisms of scenarios, learners may progressively transition away from passively inhabiting a learning environment to actively constructing learning situations, which facilitates an inquiry about and creation of knowledge.

3.1.2 Principle of Integrating Digital, Interactive, and Contextualized Approaches

Digital technology should not be an add-on, but rather seamlessly integrated into the spatial experience. Intelligent recommendation systems, multi-screen collaborative displays, mobile access, and one-stop resource retrieval platforms can all facilitate smooth interaction between digital resources and the physical environment. Real-time feedback mechanisms between students and resources, students and interfaces, and students themselves—such as screen sharing, touch interaction, and virtual collaborative environments—embody interactivity and promote discussion, presentations, and group thinking. By creating topic-based discussion areas, immersive experience zones, and creative generation areas, contextualization highlights how learning tasks, learning content, and the physical environment work together to create a "learning catalyst."

(1) Technical implementation: Virtual environment is constructed through VR/AR of metaverse

technology; remote knowledge engine is realized by digital twin; virtual self-learning is assisted by artificial intelligence; digital assets and personal privacy are managed through blockchain technology.

(2) The virtual reality framework includes: learning scenario simulation, virtual lectures by famous experts, virtual discussion groups, electronic document borrowing, experimental teaching demonstration (video or multi-dimensional), meme language learning, art learning simulation, online ideological and political classroom, and simulated academic conferences, etc.

(3) Innovation, entrepreneurship and operation model: Through virtual and real knowledge services (such as patent services and subject services), NFT model for brand promotion and reading promotion, virtual stores for cultural and creative products, virtual and real cultural circle for technological innovation and achievement transformation, virtual reality exhibitions, simulation technology exhibitions and knowledge consultation, support the knowledge innovation and entrepreneurial development of college students under the metaverse model.

3.1.3 Concept of Coordinated Layout of Resource Services and Activity Support

The traditional linear layout of "centralized resources - decentralized services" must give way to an integrated structure of "resources - services - activities" within functional zones. To facilitate resource access, capacity building, and knowledge exchange, learning spaces must simultaneously provide librarian support, digital platform guidance, workshop organization, and pathways for showcasing results. For example, learning advisors or subject librarians can be stationed near seminar areas to provide timely Q&A and assistance, and search portals can be provided for easy access to subject databases. In the area of creative practice, materials, tools, and results presentations can all be supported simultaneously. This collaborative layout enables complementary spatial functions and seamless service processes, thereby enhancing learning efficiency and knowledge transformation potential.

3.2 Self-Study Area

3.2.1 Creating Quiet Learning Space and Designing Behavioral Norms

The core role of the self-study area as an essential part of the knowledge service area of the library is to offer a stable, focused, and sustainable personal learning environment to the learners. The focus of this area, is on the total optimization of the learning environment, spatial privacy and accessibility of information. The self-study domain, though, can no longer be viewed as a conventional reading room, with the background of diversified learning practices and proliferation of attention deficit, it can be seen as an essential environment in which learning processes are deep, focused and preparation of long-term research, as well as internalization of knowledge, are enabled. Therefore, the spatial design must have a balance between silence, comfort and accessibility of resources, which results in a learning experience that is favorable to cognitive interaction and long attention. As an example, the self-study area may be divided into separate study rooms with the assistance of semi-high bookshelves, green screens, and sound absorbing partitions to create a semi-private but not closed environment. More so, the principles of reader behavior are governed by the principle of perceptible-guided-self-disciplined so that to minimize the human noise interference in the self-study area. Particularly, it is done by means of signs, informational behavioral guidance, and environmental stimuli, as learners will naturally acquire common behavioral norms, like speaking softly, moving silently, maintaining equipment silent.

3.2.2 Personalized Learning Seat Configuration and Privacy Support

Preferences for posture (e.g., sitting upright, reclining, kneeling), information processing techniques (visual priority, text analysis, diagram integration), and attention span are just a few examples of the notable individual differences in learning behaviors. Accordingly, self-directed learning environments should provide a variety of seating options to accommodate various learning tasks and personal preferences rather than relying on a single seating style or set arrangement.

Intelligent human-computer interaction through testing and assessment also provides input data for student profiles, in addition to library resource management systems and school teaching management systems. Cognitive diagnostics involves analyzing test results and data produced during the learning process to identify significant cognitive features in order to assess a student's mastery of particular knowledge units. Matching exercises with specific target knowledge points are necessary for competency testing and assessment in order to evaluate a student's present learning status. Assessment is made possible by exercises that dynamically update a student's learning capacity based on their progress.

In addition to school teaching management systems and library resource management systems, intelligent human-computer interaction through testing and assessment also provides input data for student profiles. In order to evaluate a student's mastery of specific knowledge units, cognitive diagnostics analyzes test results and data generated during the learning process to find important cognitive features. To assess a student's current learning status, competency testing and assessment require matching exercises with particular target knowledge points. Exercises that dynamically update a student's learning capacity based on their progress enable assessment.

To provide long-term support for student learning, student portfolios must be flexible, updating and iterating as learning progresses, cognitive abilities improve, or new interests emerge.

3.3 Collaborative Learning Area

This is because the self-study area is a vital component of the knowledge service area of the library since it provides a stable, focussed, and sustainable personal learning context to the learners. The area of concern, is on the overall maximization of the learning environment, space privacy and availability of information. The realm of self-study, however, could not be regarded as a traditional reading room any longer, as the background of diversified learning practices and the proliferation of attention deficit, it can be considered as a necessary environment where the learning processes become profound, concentrated, and allow preparation of long-term research, as well as the internalization of knowledge. Therefore, the spatial design should contain a balance between silence, comfort, and accessibility of resources, which leads to a favorable learning experience to cognitive interaction and long attention. There are several examples of this, such as the self-study area can be separated into individual study rooms with the help of semi-high bookshelves, green screens, and sound insulated partitions to be a semi-privacy but not closed learning space. To a greater extent, the principles of reader behavior are controlled by the principle of perceptible-guided-self-disciplined that can help to reduce the human noise interference in the self-study area. In especial, it is accomplished through signs, informational behavioral guidance and environmental stimuli since the learners naturally develop typical behavioral norms, such as speaking subtly, moving silently, keeping equipment silent.

In addition, librarians or learning assistants can provide professional guidance at key points to help learners avoid discussions going off-topic or becoming superficial and repetitive.

Through the structured support and reasonable management provided by the library, collaborative learning areas not only promote the sharing of knowledge outcomes among learners through interaction, but also help learners form a shared understanding of learning values, further

promoting knowledge co-construction. Combined with the "reservation-use-management" rules of seminar rooms, the library can ensure the orderly conduct of knowledge creation and exchange activities, improving the efficiency and collaboration capabilities of the entire learning community.

3.4 Innovation Practice Area

3.4.1 Construction of Maker Spaces and Experimental Learning Scenarios

In future learning centers, innovation practice areas can no longer be independent spaces separate from library collections, but rather knowledge-generating spaces linked to dynamic knowledge organization systems. As university library resource organization gradually shifts from traditional linear classification systems to "knowledge networks" built on neural network semantic association models, learners' exploration and experimental activities in maker spaces can obtain more relevant and inspiring knowledge input with system support. For example, DeepSeek's natural language intent parsing capabilities can transform learners' creative descriptions, topic ideas, or questions into real-time push notifications of interdisciplinary resources, breaking through the linear path of "finding resources by category—then applying them," and enabling an instant cycle of "finding—understanding—application."

Therefore, maker spaces not only serve the function of "moving from understanding to creation," but also become the site of knowledge reorganization and re-expression. This area should, through the systematic configuration of technical equipment, experimental tools, and collaborative support mechanisms, transform learning from "resource input" to "problem-driven and outcome-generating," promoting learners' cognitive advancement and ability transformation from conceptual thinking to prototype construction in real or quasi-realistic contexts.

3.4.2 Support for Immersive Technologies such as VR/AR and Human-Computer Interaction

Smart libraries provide reading, learning, teaching, research, and academic research services to meet the personalized needs of readers. The establishment of virtual learning centers and virtual research centers utilizes virtual spaces to satisfy readers' personalized needs, and their foundation is virtual digital humans.

Information exchanged in cyberspace must undergo third-party processing and rigorous peer review before formal publication. This article categorizes formal information exchange channels in cyberspace into electronic resources (such as e-journals and e-books), open access journals, and online journals based on different publishing models.

This article specifically refers to electronic assets with corresponding print versions, such as ebooks and ejournals, as well as electronic versions of conference proceedings and dissertations. These are an extension of formal information exchange on the traditional internet, representing online service forms of digitized traditional print publications. Following user naming conventions, this article refers to them as ebooks and ejournals. By digitizing print materials, including various ejournals and ebooks, traditional scientific literature publishers and service providers offer online database services. Currently, many databases adopt this model.

E-books and journals are important forms of formal academic exchange. Numerous digital academic publishing platforms have established rich online book databases covering journals, conference papers, patents, requirements, and other materials. Libraries receive abstract and index databases for their use and retrieval. These databases are created by abstract and index service providers that collect literature from online publications and e-books and generate abstracts and indexes according to library science and indexing needs. Publishers sell e-journals using traditional subscription models and strictly control user access, such as through technologies like user

passwords.

3.4.3 Service Model Supporting Knowledge Transformation and Prototype Creation

To effectively transform ideas into tangible results, the innovation practice zone needs to establish a comprehensive service support model, including creative guidance, skills training, prototype iteration guidance, and channels for showcasing results. For example, subject librarians, industry mentors, or technical assistants can provide periodic workshops and project consultations to assist learners in design analysis, model testing, and version improvement. Simultaneously, a platform for publicly displaying and sharing feedback on results should be established, such as project showcases, digital result repositories, or student innovation case studies, enabling learning outcomes to be evaluated, optimized, and disseminated through exchange. Through this closed-loop support of "resources—skills—showcase," the innovation practice zone can promote the real output and continuous evolution of knowledge practice outcomes.

3.5 Digital Information Literacy Enhancement Area

The Digital Information Literacy Enhancement Zone aims to help learners master core competencies such as information retrieval, resource selection, knowledge management, and digital tool application, enabling them to make effective judgments, integrate information, and express themselves innovatively in a multi-source information environment. The retrieval and generation process is the core of building an intelligent library information retrieval system based on Retrieval-Augmented Generation (RAG). First, a vector database is created by segmenting the library's vast academic literature collection. Second, a question-answering generation model and a retrieval enhancement model are constructed. When a user asks a question, the retrieval enhancement model uses the vector database to search for digital resources in the local library and submits the results, along with external data, to the question-answering generation model. After verifying the response, a large-scale language model, combined with its own language model and prompting engineering techniques, accurately generates the target response. The entire retrieval process consists of three parts: dialogue generation, model building, and data establishment. The specific process is as follows: data extraction → text segmentation → vectorization → data storage in another vector database → user query → data retrieval and retrieval → prompting information integration → large-scale language model generates the response.

4. Pilot Validation Plan: Qualitative Research

4.1 Research Objectives and Background

This study aims to evaluate whether the implementation of measures such as the hierarchical design and flexible scheduling of group discussion rooms, the configuration of communication equipment, and collaborative learning support mechanisms in the collaborative learning area of the library effectively promotes learners' interactive communication, knowledge construction, and collaborative abilities. Pilot testing further examines the effectiveness of the management model and space design strategies proposed in this paper in improving and optimizing the library's learning environment.

4.2 Pilot Targets and Scope

The pilot program is conducted in a university library, selecting two to three seminar rooms that have already implemented collaborative learning area designs as experimental subjects. Participants

include faculty and students who study and conduct research in the library, especially frequent users of the collaborative learning areas, subject librarians, and learning support staff.

4.3 Methods

4.3.1 Observation Method

By conducting on-site observations in the pilot area, information was collected regarding learners' interactions in the group discussion rooms, equipment usage, and the discussion atmosphere, and the following aspects were evaluated:

Learner interaction patterns: Observe how learners interact with devices such as multi-screen sharing systems and portable writing tablets to see if it can effectively promote group thinking and knowledge integration.

Equipment usage frequency and satisfaction: Record the frequency of equipment use, problems encountered, and learners' satisfaction with the equipment configuration.

Learning Outcomes: By observing the learners' discussion process, assess whether they are able to shift from "information sharing" to "co-generating knowledge".

4.3.2 Interview Method

Semi-structured interviews were conducted with learners, subject librarians, and learning tutors participating in the pilot program to understand their perspectives and experiences with the collaborative learning zone improvement measures. The interview content mainly included:

User experience of the group discussion room: Did you feel that the space design and management rules effectively supported the smooth progress of learning tasks, and did it help to stimulate innovative thinking?

Device configuration and support: Do you believe that the configuration of devices such as multi-screen sharing and portable writing tablets improves the collaboration and efficiency of learning?

The role of collaborative learning support mechanisms: whether subject librarians have played an effective role in guiding the learning process, and whether the support mechanisms have helped learners deepen their knowledge construction.

4.4 Literature

By analyzing relevant literature and learning outcomes from the pilot period, this study assesses the changes in the quantity and quality of academic outputs or research reports, as well as learners' performance in areas such as paper writing and project discussions, after the implementation of the collaborative learning area. A comparison of learning outcomes before and after the pilot period allows for an evaluation of improvements in innovative thinking and changes in problem-solving abilities.

Through thematic analysis of interview records and observation notes, the successful experiences and problems of the library's implementation measures are extracted, and the different perspectives of subject librarians and learners are compared to reveal the effectiveness of collaborative learning areas.

(1) Feelings of subject librarians

1) Successful experience

Subject librarians generally believe that the design and management of collaborative learning areas enable them to more effectively guide learners to engage in in-depth thinking and collaborative discussions.

In a discussion on the theme of "Digital Technology Empowering the Transformation of the Teacher's Role in Classroom Education," subject librarians not only provided students with relevant literature to support their arguments but also helped them use knowledge graphs to break down the key issues into logical points at different levels. Through this discussion, students progressed from a superficial understanding that "technology changes teaching tools" to a deeper perspective on "teachers transforming from knowledge transmitters to learning facilitators in a digital age."

The librarian said, " In the past, I mostly provided resources, but now I can truly enter their thought processes and help them form cognitive structures. It's very fulfilling, and I feel that because of this guidance, students are exploring the topic more deeply."

2) Spatial design flexibility

It is an interdisciplinary seminar, which is organized by students of education and computer science majors called AI Empowering Basic Education Classrooms. The students sit in a collaborative learning area where they are encouraged to sit in a circle of shared discussion space with movable whiteboard whereby every member of the group equally contributes to the discussion and gives his/her opinion. Four members were provided with a multi-screen sharing system, which offered them a chance to project at a time the resources they were being sought (as policy texts, technical case studies, and video examples in classrooms) that they required.

The Computer Science student A demonstrated in the discussion the technical reasoning of an online classroom feedback system on the computer display, and Education student B was simultaneously writing on a whiteboard the scenarios of supported teaching activities and the potential classroom interaction techniques. Due to the free and open nature which allowed the members of the group to switch between different perspectives of resources, they could complete each other, ask questions and argue with each other and, at that, the discussion was logical and highly interesting.

One of the librarians who responded to the interview asserted that the portable writing board does not make the content of the thinking to be more so, but only allows them to present in a short-time span the abstract ideas; multi-screen sharing would also ensure that no one is an independent researcher but one who can see and respond instantly, which will directly translate to the deeper aspect of the conversation.

3) Co-ordination of different devices

Others suggested that information sharing becomes easier in real time due to the multi-screen sharing as well as wireless projecting devices during meetings and discussions when dealing with complex problems. Personal thoughts can be viewed as they are and corrections made to the discussion on the spot.

4) Demand pressure on equipment and management.

Although the librarians believe that nothing is wrong with the equipment set up, they too have noticed that the equipment set up has posed a new challenge towards the areas of management. Reservation and scheduling conflicts arise especially during peak hours where not much of space and equipment can serve certain groups of studies so that some of study groups may not have an opportunity of using the equipment at the appropriate time and therefore the impact of the learning process.

5) Weaknesses of librarian instructions.

Other librarians showed that despite the provision of the requisite support tools in the frequent and open ended discussions, there were numerous disparate backgrounds of the group that did not enable taking care of all the groups in totality. In particular, it was only a more complex case of the academic discussion topics that demanded the additional subject-specific instructions and individual support.

This feedback can provide a reference for future library space design and management, and can

serve as more empirical evidence to further confirm the effectiveness of collaborative learning space design in improving learning outcomes.

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