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Research on Space Reconstruction and User Experience Optimization of University Libraries from the Perspective of Digital Transformation

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Abstract: Digital transformation is profoundly reshaping the spatial form and service logic of university libraries. This article starts from the perspective of digital transformation, systematically analyzes the current bottlenecks and transformation directions of spatial reconstruction in university libraries, and proposes four reconstruction paths: shifting from book orientation to user orientation, designing smart learning spaces that integrate virtual and real elements, reshaping collaborative innovation and immersive spaces, and improving spatial configurability and dynamic adaptability. On this basis, a four-dimensional framework for optimizing user experience is constructed: scenario based services enhance cognitive fluency, data-driven personalized environment adaptation, embedded support for social and collaborative experiences, and emotional experience and spatial belonging creation. The linkage mechanism between technology, space, and experience jointly promotes the evolution of libraries from resource storage to a smart learning ecosystem. The research provides a systematic spatial reconstruction strategy and experience optimization path for the digital transformation of university libraries.

Keywords: Digital Transformation; University Library; Spatial Reconstruction; User Experience Optimization

1. Introduction

Digital transformation is profoundly reshaping the higher education ecosystem, and university libraries, as the core carriers of academic support and learning spaces, are facing fundamental changes in their functional positioning and service models. Traditional library spaces, centered around document collection, struggle to respond to the diverse needs of digital age users for flexible learning, collaborative co creation, and immersive experiences. How to use digital technology to promote spatial reconstruction and systematically optimize user experience on this basis has become a key issue in the transformation of current university libraries. This article analyzes the current situation and bottlenecks of spatial reconstruction in university libraries from the perspective of digital transformation, explores the user oriented path of spatial function transformation, and proposes a user experience optimization strategy based on spatial reconstruction, in order to provide theoretical reference and practical inspiration for the construction of smart libraries.

2. Current Situation of Digital Transformation and Spatial Reconstruction of University Libraries

2.1 Progress of Digital Transformation in University Libraries

Currently, the digital transformation of university libraries has moved from partial exploration to a systematic promotion stage. At the hardware level, RFID self-service borrowing and returning, intelligent bookshelf reservation, self-service printing and scanning devices have become standard equipment in most undergraduate colleges, and some leading libraries have also introduced inventory robots, intelligent bookshelves, and contactless borrowing channels. At the software and service level, the mobile library app, WeChat mini program, and electronic resource unified retrieval platform have been widely covered, and functions such as remote access to resources, online appointment of seminar rooms, and virtual reference consultation are gradually improving[1]. At the same time, some universities have begun to explore cutting-edge applications such as virtual simulation reading rooms, digital humanities laboratories, and IoT based environmental intelligent control. Overall,

digital infrastructure is upgrading from "usable" to "imperceptible", and technology embedding is changing the spatial operation logic and service touchpoints of libraries, providing technical support for spatial reconstruction.

2.2 Main Bottlenecks Faced in Spatial Reconstruction Practice

Despite the continuous increase in investment, the spatial reconstruction of university libraries still faces multiple bottlenecks. Firstly, the planning concept is lagging behind, and many renovations still remain at the hardware repair level of "adding seats or charging ports", lacking systematic design for learning behavior, social needs, and virtual real linkage. Secondly, there is a disconnect between technology and space. Although smart devices have been installed, the data between systems is not connected, the operation is cumbersome, and the maintenance cost is high, resulting in "building but not using" or "using but not smooth"[2]. The third issue is uneven distribution of resources, with prominent supply-demand contradictions in popular seminar rooms, exam season seats, and some functional areas remaining idle for a long time. In addition, there are conflicts between traditional management mechanisms and flexible space requirements, such as fixed opening hours, rigid appointment rules, and difficulties in cross departmental coordination, which seriously restrict the ability to dynamically allocate space. These bottlenecks are essentially structural mismatches between technology introduction and management systems, as well as user demands.

2.3 Challenges Posed by Changes in User Experience Needs to the Current Situation

The profound changes in user learning behavior and information acquisition methods are forcing the library space to accelerate its reconstruction. On the one hand, self-directed learning, group collaboration, and interdisciplinary project-based learning have become mainstream. Users are no longer satisfied with "quiet self-study", but need discussion spaces that can be divided and combined, collaborative devices that can be displayed at any time, and integrated online and offline resource support. On the other hand, digital native users have extremely high requirements for process efficiency, and have low tolerance for issues such as cumbersome operations, response delays, and information silos. Any "bad" experience will directly reduce their willingness to use[3]. At the same time, remote and blended learning has become normalized after the epidemic, and users expect the library space to support mixed scenarios such as online conference access, virtual seminars, and live courses. More importantly, emotional experience is becoming increasingly prominent - the comfort of space, design aesthetics, cultural atmosphere, and sense of belonging have become important factors for users to choose. These changes require spatial reconstruction to shift from "collection centric" to "user experience centric".

3. Spatial Reconstruction of University Libraries Under Digital Transformation

3.1 Spatial Functional Transformation from Book Oriented to User Oriented

Traditional libraries rely on the volume of books as the core indicator, resulting in a large amount of space being occupied by dense bookshelves and squeezing the reader activity area. The digital transformation has broken this pattern, and RFID and intelligent warehousing technology have made high-density automated book storage possible, returning physical space to users[4]. The spatial function has shifted from "book storage" to "education", the reading area has evolved into a learning area, and the single static reading has expanded into diverse activities. User orientation means dividing space based on learning behavior rather than literature categories, such as individual deep learning areas, group collaboration areas, maker practice areas, etc. This transformation is essentially a shift in value orientation: space no longer serves collections, but rather serves people's needs and experiences.

3.2 Smart Learning Space Design with Virtual Reality Integration

The integration of virtual and real is core characteristic of digital transformation, and this is reflected in library space, where physical environment and digital services seamlessly connect. When users enter discussion room, desktop screens can automatically synchronize data from their personal cloud drives, with scanning seat QR code allowing adjustment of lighting color temperature and arrangement of printing tasks. Smart learning space also embeds virtual reality terminals and digital twin systems,

thereby enabling remote users to 'enter' library and participate in activities. Key of design lies in breaking boundaries between online and offline, making technology invisible and services visible, which links with user profiles through Internet of Things, thus enabling space to anticipate needs and respond proactively, achieving fundamental transformation from 'people finding resources' to 'space finding people'.

3.3 Collaborative Innovation and Immersive Experience Space Reshaping

University libraries are transforming, moving from repositories of knowledge toward innovation incubation platforms, giving rise to collaborative innovation spaces, which includes reconfigurable team studios, maker spaces equipped with 3D printing and audio-video production equipment, and also encompasses academic exchange pods that support interdisciplinary dialogue. At same time, immersive experience spaces utilize technologies such as VR/AR, holographic projection, and multi-channel curved screens, constructing scenarios such as virtual simulation experiments, historical scene recreation, and data visualization interaction, with such spaces not only serving teaching and scientific research, but also enhancing cultural appeal of libraries. juxtaposition of collaboration and immersion both satisfies group collaborative needs of project-based learning, and deeply provides individual cognitive engagement experiences, thereby forming compound learning ecosystem.

3.4 Space Configurability and Dynamic Adaptability Enhancement

Digital transformation has endowed space with unprecedented flexibility, while Traditional fixed partitions and immovable furniture have been replaced by modular tables and chairs and movable partitions, with the form of space being quickly switched according to needs, in morning it is lecture hall, in afternoon it is divided into three discussion groups, thus converting into quiet self-study room in the evening. Intelligent reservation system and space management platform monitor usage data in real time, identify peak periods and idle periods through heat maps, and automatically adjust open strategies and resource allocation, with dynamic adaptation also being reflected in personalization, which allows users to preset seat parameters through app. This configurability makes library space no longer a static container, but an organic component of a responsive learning ecosystem.

4. User Experience Optimization Path based on Spatial Reconstruction

4.1 Scenario Based Services Enhance User Awareness and Operational Fluency

Scenario-based service, with its core in embedding scenarios, embeds various library resources and services into users' specific learning, research, and collaboration scenarios, thereby significantly reducing users' cognitive burden and operational costs, while under traditional mode, users borrowing books and reserving seminar rooms often need to repeatedly switch between different systems, log in multiple times, and memorize multiple sets of operational procedures, which severely disrupts learning experience due to this fragmented interaction mode. Digital transformation provides foundation for this, and through unified identity authentication and intelligent middle platform, library can integrate scattered functions such as seat reservation, literature retrieval, space booking, equipment use, and reference consultation into a 'scenario-as-a-service' mode, with a notable example being when user enters discussion room and prepares to carry out group project, the system automatically identifies course theme, pushes relevant collection resources and datasets, and exports notes, files, and references generated during discussion to personal learning space with one click, thus enabling another scenario of thesis writing, where user can automatically adjust lighting in space, while quickly invoking literature management tools and writing assistance plugins, and noise level adapts accordingly. In essence, scenario-based service transforms 'user adapting to system' into 'system adapting to user', thereby ensuring that every interaction is highly aligned with current task objectives, with this scenario-based service encapsulation not only significantly improving operational efficiency, but also truly endowing space with experiential quality of 'intelligent companionship'.

4.2 Adaptation of Data-Driven Personalized Learning Environment

So-called data-driven personalized learning environment adaptation refers to dynamically adjusting physical spatial parameters, resource

delivery and service delivery methods based on users' behavioral data, learning trajectories and preference characteristics, so that each user can obtain differentiated spatial experiences, while in traditional libraries, 'one size fits all' space requires users to actively adapt to environment, and digital transformation has made it possible for environment to reversely adapt to users, by collecting multi-dimensional data such as seat usage frequency, dwell duration, resource retrieval records, and device call types, the system can construct user profiles and identify their typical learning patterns, for example, when a user who frequently participates in group discussions enters a seminar room, light brightness, screen projection mode and noise isolation level will automatically switch to collaborative mode, with users who prefer deep reading having the system dim surrounding lights, push their unfinished e-books, and block unnecessary notifications after they take a seat. In addition, machine learning algorithms can predict users' spatial needs at different time periods and task types, such as proactively reserving fixed seats during exam preparation phases, or recommending workstations equipped with high-performance terminals during project intensive periods, with personalized adaptation also needing to balance privacy protection and data usage boundaries, adopting localization and anonymization mechanisms to reduce users' concerns, when space can 'remember' users' habits and respond to expectations in advance, the library is no longer a cold physical container, but an intelligent learning partner that accompanies users' growth, thereby transforming spatial reconstruction into experience optimization through this data-driven dynamic adaptation capability, which represents the key technological path toward truly responsive learning environments.

4.3 Embedded Support for Social and Collaborative Experiences

This concept emphasizes organically integrating various functions required for interpersonal interaction and teamwork into design of space, thereby transforming collaborative behavior from "spontaneous and incidental" to "accessible everywhere". Traditional libraries are dominated by silent reading, and social and collaborative activities are often regarded as disturbances to order, thus being marginalized.Digital transformation has redefined the social attributes of space: through intelligent reservation systems and spatial perception technology, libraries can achieve dynamic and static zoning and time reuse within the same building, ensuring the quiet needs of deep learning and providing sufficient and friendly places for discussion, co creation, and interdisciplinary communication. Specifically, the collaboration space should be equipped with tools such as one click screen casting, multi-party video access, shared digital whiteboards, remote collaborative editing, etc., to enable online and offline members to participate in discussions without discrimination. At the same time, embedded support is also reflected in the service process - when the group appointment is successful, the system automatically pushes related literature, statistical data analysis tools, and opens an appointment channel for embedded consultation by librarians. The creation of social experiences should not be limited to functional aspects. Informal communication nodes in the spatial flow, such as collaboration stairs, writable walls, and light discussion bars, can catalyze inspiration collision and knowledge overflow. At a deeper level, by connecting user identity and collaboration records, libraries can intelligently recommend teams or potential partners with similar research interests, and build a weakly connected network based on academic socialization. When collaboration shifts from spontaneous user behavior to systematic spatial support, libraries surpass the traditional positioning of resource repositories and truly become catalysts for knowledge co creation and social learning.

4.4 Creating User Emotional Experience and Sense of Spatial Belonging

The creation of user emotional experience and spatial belonging focuses on psychological connection and cultural identity beyond functional satisfaction. In the highly digitized era, if libraries only emphasize efficiency and technology, they are prone to falling into the trap of "cold intelligence" and weakening users' emotional attachment. The generation of a sense of belonging stems from the response of space to individual identity, memory, and aesthetic needs. The specific creation path includes: introducing natural lighting, green plant landscapes, and soft sound environments to reduce cognitive fatigue; Set up reading corners or school history memory exhibition areas with disciplinary cultural

themes to enable the space to carry collective narratives; Reserve a certain proportion of "blank space" for users to independently arrange small exhibitions or carry out interest community activities, enhancing their sense of participation and ownership. In addition, the intelligent environment system can adjust the color temperature of lights and background music by recognizing the user's emotional state, and provide emotional support facilities such as decompression chambers or meditation corners during the final week. Long term retained behavioral data can also be used for personalized spatial storytelling, such as pushing users micro review functions such as "where you used to sit a year ago today". The ultimate goal of emotional experience is to make users feel "seen" and "cared for", thereby elevating the library from a functional place to a spiritual habitat. When users develop emotional dependence and identity recognition towards space, active use, spontaneous maintenance, and cultural dissemination become natural extensions, which is the deep value pursued by spatial reconstruction and experience optimization.

5. Conclusion

The digital transformation provides fundamental driving force for the spatial reconstruction and user experience optimization of university libraries. This study indicates that the core of spatial reconstruction lies in shifting from book collection orientation to user orientation, reshaping the physical and digital boundaries of libraries through virtual real integration, collaborative innovation, and dynamic configurable design. On this basis, user experience optimization needs to simultaneously promote four paths: scenario based services, personalized adaptation, collaborative embedding, and emotional belonging creation. The linkage mechanism of technology, space, and experience forms a spiral upward trend: technology empowers spatial transformation, space carries experience upgrades, and experience feedback drives technological iteration. In the future, university libraries should further break through organizational barriers and data silos, establish a spatial governance system centered on the user lifecycle, and truly become an irreplaceable hub for learning, creation, and communication in smart campuses.

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