

Design Process and Implementation Strategies for University Library Learning Spaces: Post-print

Authors: Ding Pei, Hu Zhenning

Date: 2023-07-26T00:00:00+00:00

Abstract

[Purpose/Significance] Library space serves as a crucial venue supporting university users' activities in learning, research, teaching, and related endeavors, representing a strategic development direction for future university libraries. This study investigates the design processes and implementation strategies of library space projects to provide reference and guidance for the construction of learning spaces in university libraries. [Method/Process] Based on literature review and case analysis, this research approaches from the project process perspective to analyze the procedures of university library space project planning, requirements collection and analysis, conceptual design, element design, service design, and space evaluation, elucidating the key points, implementation methods, and best practices for each process. [Results/Conclusion] The study summarizes five strategies for implementing library space projects: user-centered design, alignment with university strategic development, maintaining space flexibility, integration of space and services, and extensive collaboration with campus partners.

Full Text

Preamble

Vol. 63 No. 16 August 2019

Design Process and Implementation Strategy for University Library Learning Spaces

Ding Pei^{1,2,3} Hu Zhenning³

¹ National Science Library, Chinese Academy of Sciences, Beijing 100190

² Department of Library, Information and Archives Management, University of Chinese Academy of Sciences, Beijing 100190

³ Shenzhen University Library, Shenzhen 518060

Abstract

[Purpose/Significance] Library space is a crucial venue supporting university users' learning, research, and teaching activities, representing a strategic development direction for academic libraries. This study examines the design process and implementation strategies for library space projects to provide reference and guidance for university library learning space construction. **[Method/Process]** Based on literature review and case analysis, this paper analyzes the planning, demand collection and analysis, conceptual design, element design, service design, and evaluation processes of university library space projects from a project flow perspective, explaining the key points, implementation methods, and best practices for each stage. **[Result/Conclusion]** The paper summarizes five strategies for implementing library space projects: user-centered design, alignment with university strategic development, maintaining spatial flexibility, integration of space and service, and extensive cooperation with campus partners.

Keywords: library space; space project flow; space design; spatial element; space service

Classification Number: G250.7

DOI: 10.13266/j.issn.0252-3116.2019.16.007

1. Development and Research Status of Library Space

Over the past two decades, the architectural philosophy of university libraries has gradually shifted from collection-centered to multi-service-oriented, leading explorations in spatial transformation. Early spatial renovation practices established relatively centralized information commons, providing one-stop services for literature resources, reference consultation, and technical support. In the early 21st century, with deepening educational reforms and ubiquitous learning approaches, library information commons gradually incorporated functions for individual learning, collaborative research, and social learning, evolving into learning commons. Learning commons break through centralized layouts, with various types of spaces distributed across different areas of the library, offering differentiated personnel, resources, and technical services to support different learning modalities. Libraries have also collaborated with academic service institutions to enhance spatial service capabilities in areas such as thesis writing, language learning, IT experiences, and distance education. In recent years, some foreign university libraries (such as North Carolina State University' s Hunt Library, University of Massachusetts Amherst' s Dubois Library, and Purdue University' s Hicks Library) have transformed the entire library into learning spaces, representing a new direction in library spatial transformation. These innovative initiatives have not only gained full user recognition but also become hot topics and research priorities among peers.

Numerous scholars have conducted in-depth research on conceptual understanding, demand transformation, spatial design, case analysis, and spatial evaluation of university library learning spaces. L. Fallin argues that university libraries

need to elevate the concept of learning spaces from the physical level to the user cognition level, and that user participation in the library spatial transformation process is an effective way to promote the “library as learning space” concept among users. M. Savin-Baden proposes that learning spaces are metaphorical, representing psychological spaces people create for reading, researching, reflecting, and writing, with different internal needs requiring different external spatial configurations. L.Y. Ren, A. Ferria, and L.S.J. Farmer use empirical research methods such as observation, questionnaires, and interviews to demonstrate that library spaces need to flexibly support diverse faculty and student research and teaching needs. Chen Jing, D. Robson and P. Durkee, and K. Keyes introduce processes for developing new types of spaces (such as makerspaces, game labs, and family learning spaces) in academic libraries to meet specific user needs. S.E. Montgomery, K.M. Soria, and C. Andrews evaluate the effectiveness of library learning spaces from perspectives such as user behavior, how spaces support user output, and whether user needs are met. G. Matthews and G. Walton, Guo Weining, and Xiao Long introduce implementation experiences from cases such as Loughborough University Library’s space renewal, North Carolina State University’s new Hunt Library, and Peking University Library’s old building renovation.

These studies demonstrate changes in university library spatial needs and explore practical cases of spatial transformation, providing important reference value for new space projects. However, the authors note that these studies pay relatively little attention to library spatial design processes and project implementation procedures. Some foreign institutions, such as the UK’s Joint Information Systems Committee (JISC), the Association of College and Research Libraries (ACRL), the UK Higher Education Learning Space Toolkit Project Team (hereinafter referred to as the UK Project Team), and the North Carolina State University Library Learning Space Toolkit Project Team (hereinafter referred to as the NCSU Project Team), have published multiple learning space design guidelines containing spatial design process information. Although not specifically targeted at libraries, these guidelines are highly valuable for reference. Hunt Library’s experience in learning space construction based on project processes is also worth studying and sharing.

This paper focuses on library spatial design process management, combining library spatial transformation practice cases to examine the core elements and implementation methods of each design stage, proposing concepts and implementation strategies for library space construction to provide reference and guidance for university libraries advancing learning space construction.

2. Library Space Project Design Process

The UK Project Team, composed of the Universities and Colleges Information Systems Association (UCISA), the Association of University Directors of Estates (AUDE), and the Standing Conference for Heads of Media Services (SCHOMS), collaborates from different perspectives to study modern higher ed-

ucation concept-based campus learning space construction. They divide learning space projects into eight stages: strategic setting, project preparation, conceptual design, detailed design, technical design, construction, handover, and use. The Hunt Library project process is divided into vision, planning and design (including user research, spatial attribute setting, and pre-design), site analysis, physical modeling, sustainability analysis, and cost management. The NCSU Project Team divides university learning space project operation processes into stages such as project roadmap, needs analysis, space type design, service design, technical design, and integration. Although these libraries have unique characteristics in spatial design, they basically follow a “planning-demand-design-evaluation” process from a project management perspective. and provide detailed analysis of the design processes of multiple typical cases. Based on the implementation experience of these actual projects and the spatial project guidelines mentioned above, the authors subdivide the university library spatial design process into six stages: project planning, demand collection and analysis, conceptual design, spatial elements design, spatial service design, and spatial evaluation, analyzing the key points and considerations for each stage.

2.1 Planning

Project planning serves as the foundation and basis for all project work. Through project planning, the development vision and objectives for university library spaces are described, preliminary construction costs and daily operation costs are analyzed, budgets are formulated, and project timelines are established.

The key focus of project planning is team formation. G.T. Freeman, an engineer and senior library space designer at the American Institute of Architects (AIA), believes that before designing library space requirements, a team should be formed comprising the library director, administrators, university council members, students, and faculty. Team members should possess not only long-term strategic vision but also strong communication skills.

Project planning must first ensure direction, guaranteeing that the project serves the university’s mission and strategy. The project team should thoroughly study national or industry higher education reports (such as the Horizon Report), university development strategies (such as foreign universities’ strategic plans and domestic universities’ “13th Five-Year” plans), and explore teaching and learning trends in higher education as the basis for formulating spatial planning visions and objectives. Second, emphasis should be placed on data analysis to ensure spatial practicality and flexibility. The project team should observe behavioral details and information technology proficiency levels of students in learning contexts, collect basic student data and learning behavior data from relevant university departments, and formulate reasonable and practical project plans through big data analysis. Third, communication should be strengthened to ensure transparent processes, reasonable budgets, expected outcomes, and evidence-based decision-making. The project team needs to establish effective

communication and feedback mechanisms, using project interviews, academic conferences, websites, blogs, WIKIs, and mailing lists to widely solicit opinions from all parties. Not only should space users (such as students, faculty, and researchers) be surveyed, but close contact should also be maintained with senior administrators (such as the president and academic committees) and university units (such as finance departments, academic affairs departments, and information centers). At each stage of project planning, repeated communication with all parties should be conducted to obtain their approval.

Through the above three aspects of work, the planning team completes the *Project Planning Document*, establishing project objectives and preliminary budgets. After approval by higher authorities, the project proceeds to detailed demand analysis and conceptual design stages.

2.2 Demand Collection and Analysis

Demand collection involves investigating from readers what kind of space they need, what equipment and services they require in the space, and how they study individually or collaboratively. Through demand analysis, gaps between existing spaces and user expectations are identified to improve learning space design.

Common demand collection methods include five types: observation, individual interviews, photo diaries, focus groups, and surveys, each with its own advantages and disadvantages as analyzed in . In practice, libraries implementing space projects comprehensively adopt different methods to collect data on current space usage and user potential needs. For example, Florida State University Library not only uses observation, surveys, and interviews but also encourages students to design drawings of ideal spaces. Cornell University Library spent eight years systematically collecting reader demand information using the above five methods, combined with environmental trend analysis reports, to redesign its collaborative research space. Actual cases demonstrate that user demand collection is crucial for library space construction. Based on demand collection, project teams can transform spatial planning objectives into elements supporting different user behaviors (space, technology, services), forming specific spatial conceptual designs. Simultaneously, the degree to which needs are met serves as an important evaluation metric for space assessment.

2.3 Conceptual Design

Conceptual design involves categorizing and refining user needs, anecdotes, oral expressions, or behavioral patterns to form different spatial functional requirements, mapping needs to user scenarios. Through conceptual design, the relationship between user needs or preferences and specific spaces, as well as the relationship between a particular space and related technologies or services, is described, laying the foundation for subsequent spatial elements design.

There are many conceptual design methods. The NCSU Project Team provides

two practical approaches: (1) **3W1H1C analysis**, which examines five dimensions: Who (user type), What (what users need and what they use it for), Why (motivation for the need), How (how technology supports, how services support, what factors can promote further use, how spatial attributes support), and Check (whether there are spaces that partially meet the conditions). This approach is suitable for known user classifications and helps intuitively understand key users' needs for space, services, and technology. (2) **User persona modeling**, which involves interviewing user needs, observing user behaviors, and creating user persona models based on data. This is a systematic user research method suitable for scenarios with unclear user characteristics and scattered needs, such as market analysis and user group analysis. The modeling process requires three steps: first, brainstorming based on collected needs to categorize readers; second, re-clustering and labeling readers based on more detailed behavioral analysis and user goal surveys; and finally, creating persona model frameworks based on core needs and user goals. After obtaining user persona models, role needs are converted into application scenarios, which continuously refine the persona models.

The first method is traditional and practical, allowing relatively rapid completion of conceptual design. The second method is newer and more targeted. The NCSU Project Team used the second method when designing Hunt Library. They created a virtual female student named TONYA CREW, a senior in chemical and biological engineering, as a representative of a reader category. Approaching exams, she needs a group space for discussion and collaborative learning (user goal), requiring use for over a week, equipped with projectors, large tables for displaying drawings, and allowing food and beverages (needs analysis). Items she frequently carries include calculators, large quantities of printed papers, valuable reference books, notebooks, daily planners, laptops, light jackets, and mobile phones (behavioral analysis). The project team organized this content into a user persona model and created a corresponding user scenario framework. Based on this scenario, the space project team can further design furniture placement, facility provision, and services within the space, proceeding to spatial elements design.

2.4 Spatial Elements Design

Elements design further refines conceptual design by integrating user scenarios and characteristics obtained during conceptual design into spatial layout and describing the composition details of different spaces to realize conceptual design intentions.

The elements design stage should consider the following aspects: spatial function, distribution and form, spatial environment (sound control, usage frequency, openness, temperature control, lighting requirements), furniture (comfort, flexibility, color), facilities, and other factors (whether spatial signage is clear, requirements for adjacent spaces).

University library spaces can be divided into four basic functional types: collection space, learning space, office space, and auxiliary space. Major space types can be further subdivided into sub-spaces based on needs. For different needs, each sub-space has its own environmental, furniture, and service requirements. Based on existing library space cases and research literature, and taking learning spaces as an example, the authors summarize the functional zoning and spatial elements of their subdivided sub-spaces in .

The functional zoning in does not imply that a learning behavior can only occur in one type of learning space. Rather, the design intention of a particular learning space zone tends to support certain learning behaviors, providing users with different choices and more suitable environments. The various spatial elements of functional zoning work together as an integrated whole, seamlessly cooperating to meet user needs and promote full space utilization.

2.5 Spatial Service Design

A successful library space requires not only spatial elements design that meets and balances various user needs but also appropriate technology application and adequate service provision within the space. Space, furniture, and technology are hardware guarantees, while services within the space are software support affecting user learning experiences.

Services in library spaces are bridges for communication and interaction between library staff and users. Library spaces provide services at different levels: (1) **Basic services** such as consultation, book borrowing, printing and copying, scanning, IT services, equipment lending, exhibitions, and space reservations; (2) **Subject services** such as reference consultation, information literacy training and courses, and academic services (e.g., writing centers, language services, academic conferences); (3) **Other services** such as food and beverage services, storage services, lost and found, and guidance.

In specific spaces, libraries should provide just-right services, requiring comprehensive consideration of multiple factors for targeted service design, including determining service timing, staffing, and necessary equipment. User behavior and experience requirements determine service scope; staff numbers and arrangements affect service response range and speed; and staff skills and proficiency determine service depth in library spaces. Service design in library spaces should comprehensively consider these three factors for overall planning, particularly determining spatial service scope, which plays an important role in subsequent work development.

Traditional service design methods draw on others' experiences through literature research and field observation, referencing spatial functional positioning to form service frameworks. This method summarizes service content based on existing patterns but lacks empirical investigation of user behavior and service effects, requiring continuous evaluation and adjustment. Newer service design methods utilize demand analysis tools and visualization technologies to collect

user demand behavior information for more targeted service design. The NCSU Project Team employs novel tools such as ServicePlot to assist service design: Service Location Planner brainstorms to detail what services should be provided in specific areas and time periods through checklists; Journey Maps visualize user experiences by showing user behaviors distributed along timelines and required library services at key time points; Service Blueprint Generator designs service prototypes based on the above analysis, including service types, physical facilities in service spaces, user behavior evidence, public work of frontline service staff, IT and equipment support work of back-office staff, and system support. Although the new method has issues with large survey workload and longer design time, it organically combines readers, librarians, service timing, and facilities, ensuring targeted and efficient services, which is undoubtedly an important trend in service design development.

2.6 Space Evaluation

Space evaluation refers to comprehensive analysis of library space operational effectiveness and user spatial needs to understand whether spaces fulfill intended functions and meet user demands. Space evaluation is divided into pre-evaluation and post-evaluation. Pre-evaluation assesses existing space operation before design and is embedded in the demand analysis stage. Post-evaluation assesses new space operation effectiveness after design completion. Both evaluations share commonalities in data collection methods and data analysis (such as satisfaction and usage rates), but they also differ. Pre-evaluation focuses on analyzing user usage behaviors and frequencies to summarize user needs for spatial environment, resources, and services. Post-evaluation focuses on analyzing whether various aspects of space have realized their value by combining demands, plans, and actual usage.

Different spatial design projects adopt different evaluation indicators. Commonly used indicators include user usage metrics, service provision, and facility configuration. EDUCAUSE' s Learning Initiative project has developed a rating system for evaluating learning spaces, applicable to both university learning spaces and library spaces. Evaluation dimensions are shown in .

Many library space evaluations have been conducted in foreign university libraries, with typical cases including North Carolina State University, University of Tennessee, and Northeastern University. Domestic university libraries focus more on evaluating local spaces, such as Hebei Normal University' s evaluation of reading spaces. Most existing library space evaluations are pre-evaluations, generally lacking post-evaluation. The Project Information Literacy group surveyed 22 library learning space projects in North America from 2011-2016 and found that after project completion, libraries almost never used formal evaluation indicators for assessment, with only a few using simple headcounts (34%) or resource usage (20%). The main reason is that post-evaluation requires more time, energy, professional knowledge, and operational management capabilities.

3. Implementation Strategies for University Library Space Construction

University library space design is a complex and time-consuming process. The six processes discussed above represent a complete library space design flow. A successful library space requires not only completing space design based on the process but also adhering to the following strategies during implementation.

3.1 User-Centered Design

Changes in reader needs are the fundamental drivers of changes in university library space functional layout. Modern library layout philosophy has achieved an important transformation from “resource-centered” to “people-centered.” Under the guidance of the “user-centered” concept, university libraries optimize existing space services, such as creating dedicated spaces for special groups (e.g., disabled readers, student parents) and opening communication spaces to meet high-decibel discussion needs. They also develop new space services for refined and differentiated user needs, such as Purdue University Library and University of Massachusetts Amherst’s Dubois Library providing active learning classrooms to meet students’ needs for combined online and face-to-face interaction; Shanghai Jiao Tong University Library and University of Michigan Library establishing makerspaces to encourage and support student scientific exploration; North Carolina State University’s Hunt Library and Duke University Library transforming the school’s GIS laboratory and virtual reality training room into spaces meeting students’ computationally intensive research and learning needs; and Pennsylvania State University Library introducing simulation experiment equipment to meet students’ tactile perception practice needs. These projects closely integrate with reader needs and become excellent cases of space construction.

During library space project implementation, the user-centered concept can be integrated into multiple stages. In the planning stage, users are included in the project team to hear their voices. In the demand stage, users’ actual needs and usage are surveyed as the foundation for subsequent design. In the conceptual design stage, persona modeling is used to maximize user characteristics. In the service design stage, user experience serves as the primary reference for arranging reasonable service content. In the evaluation stage, whether user needs are met serves as an important evaluation indicator of spatial value realization. Only by truly achieving user-centered design throughout the entire process can university libraries ensure they become learning spaces in users’ minds.

3.2 Alignment with University Strategic Development

ACRL’s 2010 library value report proposes that university library strategies should align with the university’s overall development strategy. L. Saunders surveyed strategic plans of 63 U.S. university libraries and found that 94.2% explicitly identified library learning spaces as strategic goals, second only to

collection development. G. Matthews and G. Walton's research found the same trend in UK universities.

During library space design, especially in the planning stage, spaces should serve the university's mission and strategy. As an important component of university space, library space development must follow the school's development goals, philosophy, and strategy. Most foreign university library space strategies mention creating first-class service spaces to meet users' changing needs and serve users' learning, research, and communication. For example, Loughborough University Library identified three strategic directions based on university strategy: library staff, digital resources, and physical space. On one hand, the library actively participates in university strategy formulation and promotes its positioning; on the other hand, it proposes detailed library strategies corresponding to each school strategy, specifically addressing space, resources, and services.

In North American higher education, student achievement has become a popular topic in recent years. Universities consider student achievement an important measure of institutional success and incorporate it into school development strategies. Regarding the "student retention" component of student achievement strategies (referring to students remaining enrolled rather than dropping out or transferring), libraries at University of Utah, San Jose State University, Utah Valley University, UC San Diego, Portland State University, and Brigham Young University launched dedicated family-style learning room services to meet the needs of student parents, supporting the student achievement strategies proposed by their universities.

3.3 Maintaining Spatial Flexibility

For years, the "modular" design concept has been popular in library architecture, emphasizing unified column grids, unified floor heights, and unified load capacities. Although the "three unifications" meet requirements for openness and transparency in library space use, they also cause waste in some spaces and limit secondary spatial design to single column grids, floor heights, and load capacities. Upon reflection, library space design has begun emphasizing fragmented concepts, manifested as design flexibility in spatial functions.

Spatial flexibility addresses both existing low space utilization efficiency and ensures continuous space vitality amid constant changes in educational paradigms and technology. Library spatial flexibility is reflected in three aspects: (1) **Design flexibility** requires library spaces to adapt to era and strategic changes, be forward-looking, and meet evolving usage needs and technological development over 10-20 years; (2) **Functional flexibility** means library spaces are no longer single-purpose; future library spaces are multifunctional, allowing one space to have multiple usage modes through adjustable furniture, equipment, and service configurations, enabling easy transformation between functions such as assembly/meeting venues, classrooms/conference rooms, and computer labs/makerspaces; (3) **Furniture flexibility** is specifically manifested as

movable and assemble-able furniture that can be configured according to reader needs.

3.4 Integration of Space and Service

Service integration into space is a major characteristic distinguishing library learning spaces from previous information commons. Traditional library services were subordinate to spatial frameworks, whereas library space design is now driven by services, with services integrated into space, making space itself a library service content. Spatial transformation involves not only room layout changes, furniture additions or modifications, and provision of advanced software and hardware but also professional, timely, continuous, and configurable technical support and services.

Library space design philosophy has shifted from traditional thinking to service-centered design. Traditional spatial design thinking treats library space design as a one-time event, with completion meaning deliverables, designing only space containers and their contents from an institutional perspective, focusing on spatial consistency and responding to changes with constancy. Service-centered design thinking, however, views design as an interactive, continuous, and iterative process, pursuing co-creation with users, adopting a user-centered design perspective, focusing on meeting individual user needs, and making spaces serve services.

The service-centered design model can help university libraries keep pace with changes, proactively supporting user learning, research, and teaching with targeted, efficient, and personalized services. This wins broader user support for university libraries.

3.5 Extensive Cooperation with Campus Partners

Within the broader campus environment, the library is not an independent service department; it is closely connected with other academic support institutions. As an important campus space component, library space serves as a carrier supporting communication and collaborative services between the library and other campus academic institutions.

The planning, elements design, and service design stages of library space design processes all emphasize library cooperation with campus institutions, considering how other campus institutions participate in library spaces and related services. Library cooperation with campus institutions occurs at different levels: (1) **Low-level cooperation** manifests as campus institutions borrowing library spaces with physical intersection but no work interference; (2) **Medium-level cooperation** involves work collaboration but separate processes, such as common library and information center co-location; (3) **High-level cooperation** is reflected in business integration, such as the popular one-stop learning commons service model in foreign university libraries.

Many foreign university library space projects provide students with one-stop learning and research service areas, the most typical manifestation of learning commons. Institutions participating in one-stop learning services include writing centers, math labs, peer tutoring, centers for teaching excellence, information literacy education, disability coordinators, diversity centers, service-learning programs, undergraduate tutoring projects, and digital centers. The Dubois Library's learning space effectively integrates the library's reference center and learning resources center with the school's writing center, Office of Undergraduate Research and Learning, financial services, and international exchange center. Staff comprises librarians, IT department personnel, student assistants, teaching assistants, and international program office personnel. Departments have both division of labor and cooperation. Librarians answer library business knowledge and questions; IT personnel address various technical issues readers encounter when using the learning commons, while guiding readers to use new IT technologies and software through interactive communication to improve their IT literacy; student assistants help readers resolve non-technical issues during learning commons use.

Active learning classrooms represent a new breakthrough in enhancing library cooperation with campus partners. Active learning classrooms are student-centered spaces where student teams practice solving course problems. Multiple foreign libraries have piloted introducing active learning classrooms into library learning spaces. The Thomas S. and Harvey D. Wilmeth Active Learning Center (WALC), newly built in fall 2017, represents a major transformation of Purdue University Library space. WALC is both a library and not purely a library. Its main body is the Library of Engineering and Science (LOES), merging resources and services from six separate libraries: chemistry, earth, atmospheric and planetary sciences, engineering, life sciences, pharmacy, nursing and health sciences, and physics. WALC emphasizes digital content resources, with only 30,000 print volumes. Based on liberated space, WALC implements a student-centered concept, creating a learning center featuring active learning classrooms complemented by collection areas, reading rooms, a Data Visualization Experience Lab (D-VELoP), the Hiler Theater, and photo walls. The learning center provides 27 active learning classrooms serving approximately 5,000 Purdue students and faculty. All active learning classrooms can be used as free library learning spaces after class. Classrooms provide multiple types of movable and combinable tables and chairs supporting different layouts (such as U-shape, T-platform) to meet different course and learning needs. This innovative model combining libraries and classrooms is gradually gaining attention from libraries both domestically and internationally.

Space is one of the most valuable assets of 21st-century libraries. University libraries strive to create learning spaces supporting campus users' learning, research, and teaching, which is an important way to perfect self-value and exert spatial benefits. University library space project design processes converge despite different approaches. The authors believe that as long as the overarching principle of user-centeredness is maintained, spatial functions are designed flex-

ibly, spatial services are made explicit, cooperation with campus partners is strengthened, and space projects follow the overall strategic direction of campus development, university library space construction can keep pace with the times and achieve sustainable development.

References

- [1] HEAD A J. Planning and designing academic library learning spaces: expert perspectives of architects, librarians, and library consultants[EB/OL]. [2018-06-13]. <https://dx.doi.org/10.2139/ssrn.2885471>.
- [2] FALLIN L. Beyond books: the concept of the academic library as learning space[J]. *New library world*, 2016, 117(5/6): 308-317.
- [3] SAVIN-BADEN M. Learning spaces: creating opportunities for knowledge creation in academic life[M]. New York: McGraw-Hill Education, 2007.
- [4] REN L Y. The academic library as place: an ethnographic study on information learning spaces for student collaboration[J]. *The iJournal: graduate student journal of the faculty of information*, 2017, 3(1): 1-10.
- [5] FERRIA A, GALLAGHER B T, LZENSTARK A, et al. What are they doing anyway?: library as place and student use of a university library[J]. *Evidence based library and information practice*, 2017, 12(1): 18-33.
- [6] FARMER L S J. Library space: its role in research[J]. *The reference librarian*, 2016, 57(2): 87-99.
- [7] Chen Jing. Research on the construction of makerspaces in academic libraries: taking American academic libraries as examples[J]. *Library and information knowledge*, 2016(3): 47-55.
- [8] ROBSON D, DURKEE P. New directions for academic video game collections: strategies for acquiring, supporting, and managing online materials[J]. *The journal of academic librarianship*, 2012, 38(2): 79-84.
- [9] KEYES K. Welcoming spaces: supporting parenting students at the academic library[J]. *The journal of academic librarianship*, 2017, 43(4): 319-328.
- [10] MONTGOMERY S E. Library space assessment: user learning behaviors in the library[J]. *The journal of academic librarianship*, 2014, 40(1): 70-75.
- [11] SORIA K M, FRANSEN J, NACKERUD S. Library use and undergraduate student outcomes: new evidence for students' retention and academic success[J]. *Portal: libraries and the academy*, 2013, 13(2): 147-164.
- [12] ANDREWS C, WRIGHT S E, RASKIN H. Library learning spaces: investigating libraries and investing in student feedback[J]. *Journal of library administration*, 2016, 56(6): 647-672.
- [13] MATTHEWS G, WALTON G. Strategic development of university library space: widening the influence[J]. *New library world*, 2014, 115(5/6): 237-249.
- [14] Guo Weining. The space revolution of university libraries: 启示 from North Carolina State University Hunt Library[J]. *Library science research*, 2016(19): 92-97.
- [15] Xiao Long. Spatial functions and layout design of libraries in the post-digital library era[J]. *Library and information service*, 2013, 57(20): 5-10.
- [16] JISC. Learning spaces[EB/OL]. [2018-06-13]. <https://www.jisc.ac.uk/guides/learning->

spaces.

- [17] ACRL. Academic library building design: resources for planning[EB/OL]. [2018-06-13]. <http://acrl.libguides.com/buildingdesign>.
- [18] The UK higher education learning space toolkit[EB/OL]. [2018-06-13]. https://www.ucisa.ac.uk/~media/Files/publications/learningspaces/Toolkit_{UK}%20HE%20learning%20sp
- [19] Learning space toolkit[EB/OL]. [2018-06-13]. <https://learningspacetoolkit.org/index.html>.
- [20] JAMES B, HUNT J R. Library programming & pre-design final report[EB/OL]. [2018-06-13]. https://www.lib.ncsu.edu/sites/default/files/huntlibrary/documents/102508_{pp
- [21] FREEMAN G T. The library as place: changes in learning patterns, collections, technology, and use[M]//Library as place: rethinking roles, rethinking space. Washington, D.C.: Council on Library and Information Resources, 2005: 1-9.
- [22] KINSLEY K, BESARA R, SCHEEL A, et al. Graduate conversations: assessing the space needs of graduate students[J]. College & research libraries, 2015, 76(6): 756-770.
- [23] Long Qian. Practice of university library space evaluation[J]. Library forum, 2016, 36(4): 79-84.
- [24] EDUCASE. Learning space rating system[EB/OL]. [2018-08-13]. <https://www.educause.edu/eli/initiatives/learning-space-rating-system>.
- [25] Qiang Jing, Huang Fumin. Research and enlightenment on American university library space evaluation[J]. Library construction, 2015(2): 92-95.
- [26] Li Dalin. Research on library space value evaluation based on LibraryCube: taking the practice of LibraryCube space value evaluation at University of Tennessee Library as an example[J]. Library science research, 2015, 6(12): 12-14.
- [27] Dong Guohua. Research on the space reconstruction evaluation system of Northeastern University Library[J]. Library science research, 2014(23): 94-97.
- [28] Liu Shaorong. Analysis of library space function and layout evaluation using POE method: taking Hebei Normal University Library' s new building as an example[J]. Library research, 2014, 44(6): 1-5.
- [29] OAKLEAF M. The value of academic libraries: a comprehensive research review and report[EB/OL]. [2018-08-13]. <http://www.ala.org/acrl/sites/ala.org.acrl/files/content/issues/value/v>
- [30] SAUNDERS L. Academic libraries' strategic plans: top trends and under-recognized areas[J]. The journal of academic librarianship, 2015, 41(3): 285-291.
- [31] FELIX E. Learning space service design[J]. Journal of learning spaces, 2011, 1(1): 1-8.
- [32] UMass Amherst libraries. Learning commons[EB/OL]. [2018-08-13]. <https://www.library.umass.edu/locations/learning-commons/>.
- [33] Wilmeth active learning center[EB/OL]. [2018-08-13]. <https://www.purdue.edu/registrar/faculty/scheduling>

Author Contributions

Ding Pei: Responsible for main paper writing and revision.

Hu Zhenning: Responsible for topic selection, structure, and content revision.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv – Machine translation. Verify with original.