An Analysis of Satisfaction with University Library Learning Spaces Based on SPSS Regression Model

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Abstract. Adopting the method of post occupancy evaluation (POE), the study space in the library of Zhuhai College of Science and Technology (ZCST) is taken as the research object, representative research items are selected, and the research and information feedback are conducted in the form of questionnaires and interviews. Optimization suggestions for college library learning space satisfaction are proposed through user character analysis, factor analysis, and regression analysis. Among them, the five research items of space capacity, color atmosphere, online reservation, digital resource satisfaction, service professionalism, and service timeliness can explain 42.1% of the variation of overall user satisfaction, and optimization suggestions are made for the four factors corresponding to these five research items: physical space, psychological environment, information resources, and supporting facilities and services, respectively.

Keywords: post-use evaluation; college libraries; learning spaces; satisfaction evaluation

1 Introduction

According to public data, since 2009, the number of applicants for national civil service exams has exceeded one million for 15 consecutive years, with about 1,576,000 in 2021, about 2,123,000 in 2022, an increase of 34.7%. In 2023, it even exceeded 2,500,000, with the final number of applicants reaching about 2,598,000. The number of applicants for master's programs has also steadily increased, from about 3,770,000

E. P. H. Lau et al. (eds.), *Proceedings of the 2024 3rd International Conference on Information Economy, Data Modelling and Cloud Computing (ICIDC 2024)*, Advances in Computer Science Research 114,
https://doi.org/10.2991/978-94-6463-504-1_22

in 2021 to about 4.74 million in 2023. As the requirement for talent becomes more demanding, the so-called "rat race" will persist, and desire to improve one's core competitiveness has become the mainstream of society, hoping to change the traditional classroom learning mode, with the demand for independent, active and cooperative learning growing. Under the double impact of technological development and changes in learning styles, library service focusing on literature borrowing and the space layout models centered on book storage are facing great challenges [1]. Nowadays, academic research on the transformation and development of libraries is gradually increasing, and libraries play an important role in higher education, assuming the role of information and culture dissemination and learning exchange in colleges and universities. Therefore, enhancing spatial attractiveness and improving space utilization rate are key focuses of constructing learning spaces in university libraries.

2 Basis of the Study

The concept of learning space emerged in the 90s of the 20th century, and research on it began in 2003, grew rapidly after the publication of "Learning Space" (Diana Oblinger, 2006), and received wide international attention after the launch of the Journal of Learning Space in 2011[2]Research on learning spaces in university libraries commenced earlier in foreign countries. The "Information Arcade," established by the University of Iowa Library in 1992, is regarded as the earliest case in the history of information-sharing spaces [3] Beagle, a scholar, first proposed the concept of information sharing space, and believed that it was changing to a learning space, arguing that the work of library learning space is not only to assist users in managing learning, but also to support users' learning activities through a series of services such as information, technology, and equipment[4]Subsequently, colleges and universities in Europe and the United States initiated a surge of research into renovating or constructing library learning spaces. In 2005, the domestic library community introduced the concept of "information-sharing space" and subsequently embarked on the revitalization and transformation of existing and new library spaces [5]. Relevant research encompasses various disciplines, including education, management, architecture, and library science. Research content primarily focuses on three aspects: 1) Research on the construction or renovation of learning spaces. Cheng Qian et al. (2022) conducted a comparative evaluation of library space expansion and renovation at two first-class universities to unearth genuine user needs for learning spaces [6]. With the advancement of science and technology, research on the construction of university library learning spaces in digital environments, utilizing virtual reality technology [7], VR technology [8], and other approaches, is steadily increasing.2) Analysis of service models and content. Song Haiyan (2010) explored the integration model of learning spaces and library disciplinary services from four perspectives: information literacy education, collaborative learning spaces, disciplinary service platforms, and knowledge communities [9]. Zheng Wenhui (2020) investigated and analyzed the current status of learning space construction in 112 "211" university libraries, summarizing their construction components and service characteristics [10]. 3) Case analysis of actual implementations. Scholars have examined

examples such as the Sun Yat-sen University Library [11], the University of Iowa Library [12], and the Hebei University of Engineering Library [13] to study the planning and implementation status and practical outcomes of these libraries.

Currently, despite the late start, research on library learning spaces in domestic settings has progressed rapidly, yielding numerous research outcomes. These outcomes predominantly revolve around learning space theory, foundational construction, spatial transformation, and case analyses. Nevertheless, research on learning space services requires further depth, and there is a paucity of studies focusing on user experience evaluation. This paper evaluates user satisfaction with learning spaces in university libraries from the perspective of post-use experiences, employing statistical correlation analysis and regression analysis methods, and supplemented with case studies to identify factors influencing user experiences in learning spaces and propose prudent enhancement strategies.

3 Study Design

3.1 Research Methodology and Approach

The Post Occupancy Evaluation (POE) method, originating from the environmental discipline, primarily focuses on users' attitudes towards completed buildings or environments. In this study, the POE method is employed to investigate the learning spaces in college libraries. The evaluation report is formed by combining the results of user questionnaires. Data collected through the POE method is processed using statistical analysis with SPSS software. Factor analysis is utilized to extract the main components of the data, verified by reliability and validity tests, followed by regression analysis to determine the extent of factors influencing user satisfaction. Based on the analysis results, recommendations are provided for university library construction to explore factors affecting satisfaction.

3.2 Questionnaire Design

The objective of this research questionnaire is to explore the relationship between college library learning spaces and factors influencing user satisfaction after use. It commences with the internal perceptions of library users and employs on-site questionnaire completion and visitor interviews as the research methodology. Literature related to university library learning spaces is collected and synthesized to identify the characteristics of these spaces. The selection principle for indicator factors emphasizes the attractiveness and appeal of the learning space to users. Consequently, 21 relevant factors potentially impacting user satisfaction with library learning spaces are identified, with explanatory notes provided for each influencing factor, as shown in Table 1. The questionnaire comprises two sections: the first part covers users' basic information and behavioral characteristics, while the second part evaluates users' perceptions of each aspect of the learning space. A five-point Likert scale [14] is utilized for this survey, with options ranging from "very satisfied (5 points)" to "very unsatisfied (1 point)", including "satisfied (4 points)"and "general (3 points)".

Table 1. Factors Influencing Satisfaction with Learning Spaces in Higher Education Libraries

factor	explanation
spatial design	Whether the space theme design is scientific and reasonable, and whether it can meet the needs of users for research and discussion
space arrangement	Whether the collection materials in the space are neatly arranged, and whether the layout of various facilities is reasonable and clean
functional partition	Whether or not to segregate the different functions of the space such as independent study area, seminar area, reading area, etc. between dynamic and static
space capacity	Whether space for independent or small group learning is provided in sufficient locations
geographic location	Convenient location of the study space within the pavilion, easily accessible so that the space is fully utilized
Library opening hours	Whether library opening and closing times meet users' learning needs
learning atmosphere	Whether the library creates a good learning atmosphere and humanistic environment, and whether it can have a positive effect on users
color atmosphere	Whether the color of the space is reasonably uniform or clearly distinguishable, attracting the user's visual level so as to produce a positive psychological effect
aesthetics	Whether the spatial sequence is designed with formal beauty, rhythmic beauty or stylistic changes in order to attract users to stay longer
sense of place	Whether the seating or other areas of the learning space are set up with a sense of domain so that users have a certain personal area
Physical Collections	Quantity and speed of updating of physical collections to meet user needs
Online Appointment	Is the online space reservation feature convenient and fast
Modernized equipment	Whether modern equipment such as computers, printers, multimedia and networks are well equipped
Satisfaction with digital resources	Whether the number and update speed of various types of e-books, literature access platforms, online courses, etc. can meet the needs of users
Degree of integration of digital resources	Whether to provide a one-stop online search platform for effective integration of resources
Communication and feedback channels	Whether open communication and feedback channels are set up in the museum, and whether comments and suggestions can be responded to
Number of space facilities	Whether the number of facilities such as tables, chairs, cubicles, lockers, lounge sofas, and guide signs in the space is sufficient and reasonable to be used
Facility Scale and Style	Whether the facility follows ergonomic size requirements and is designed to meet psychological needs

Service expertise	Whether the staff has good professional knowledge and skills, so that the help received by the user is accurate
Service Personalization	Availability of staff to pay special attention or provide effective assistance to meet the individual needs of users
Timeliness of service	Whether the staff service attitude is enthusiastic, whether the user-centered to their needs and respond quickly

4 Results and Analysis

4.1 Data Sources and Sample Analysis

To fulfill the study's objectives, a combination of online and offline methodologies was employed to conduct random sampling of questionnaires and interviews among library patrons. A total of 350 questionnaires were disseminated, yielding 324 valid responses, with an impressive response rate of 92.6%. The demographic and behavioral characteristics of the sample are meticulously detailed in Table 2.

Table 2 delineates a nearly equitable gender distribution among respondents, with males constituting 51.85% and females 48.15% of the sample. Sophomore and junior students emerged as the predominant users, comprising 31.79% and 41.36% of respondents, respectively. Concerning usage frequency, the majority reported utilizing the library 2-4 times weekly, accounting for 55.86% of respondents, with an average usage duration of 1-3 hours per visit. Over 70% of users primarily utilize the library for self-directed study, followed by leveraging its resources and facilities for academic assistance and group projects.

Table 2. Basic information and behavioral characteristics of library learning space users

sports event	form	frequency	Percentage (%)
distinguishing between the sexes	male	168	51.85
	women	156	48.15
grade	first-year university student	42	12.96
	second-year university student	103	31.79
	third-year university student	134	41.36
	fourth-year university student	45	13.89
Average number of uses per week	1 or less	59	18.21
	2~4 times	181	55.86
	5 or more	84	25.93
Average time per use	Less than 30 minutes	40	12.34
	30 minutes ~ 1 hour	87	26.85
	1~3 hours	142	43.83
	More than 3 hours	55	16.98
Primary purpose for using library learning spaces (multiple choice)	teach yourself	245	75.62
	Completion of group work	116	35.80
	Use of library equipment and resources to aid learning	186	57.41

Socializing through communication and interaction	76	23.46
Leisure (watching movies, listening to music, etc.)	38	11.73
(sth. or sb) else	18	0.056

4.2 Reliability and Validity Analysis

SPSS 19.0 software was utilized to conduct calculations on the questionnaire from this survey, aiming to assess the reliability and validity of the scale. The outcomes reveal that the Cronbach's α coefficient for the entire scale of this study is 0.914, surpassing the threshold of 0.7, indicating excellent data reliability for the questionnaire. Removal of any question item does not significantly enhance the reliability coefficient, suggesting a high level of internal consistency within the scale. Moreover, the KMO and Bartlett's tests conducted on the overall dataset yield a KMO value of 0.896. A KMO value exceeding 0.8 signifies good validity, further confirmed by the Bartlett's sphericity test, where the corresponding p-value is less than 0.05. These results underscore a robust level of credibility and construct validity within the dataset, thereby validating its suitability for continued factor analysis.

4.3 Factor Characterization

Factor analysis extracted a total of four factor eigenvalues exceeding 1, indicating robust factor characteristics. Subsequently, employing the varimax rotation method facilitated factor loading rotation, aligning the primary components with variable indicators. To elucidate the relationship between factors (i.e., principal components) and research items, a criterion from the social sciences field was applied, disregarding factor loading coefficients with an absolute value less than 0.6[15]. This approach resulted in the final rotated factor matrix (Table 3). As depicted in Table 3, the commonality value corresponding to all research items exceeds 0.5, signifying a strong correlation between research items and factors. The factors effectively extracted information, leading to their categorization: Factor 1 as supporting facilities and services, Factor 2 as physical space, Factor 3 as information resources, and Factor 4 as psychological environment.

Table 3. Rotated factor matrix

research project	**Factor loading coefficients**				**commonality (Common factor variance)**
	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	
spatial design	0.695				0.641
space arrangement	0.789				0.681
functional partition	0.733				0.679
space capacity	0.781				0.710
geographic location	0.745				0.660
learning atmosphere			0.810		0.780

color atmosphere			0.788	0.728
aesthetics			0.859	0.784
sense of place			0.841	0.749
Physical Collections		0.729		0.629
Online Appointment		0.750		0.662
Modernized equipment		0.789		0.645
Satisfaction with digital resources		0.752		0.624
Degree of integration of digital resources		0.792		0.686
Number of space facilities	0.714			0.556
Facility Scale and Style	0.774			0.677
Library opening hours	0.754			0.596
Communication and feedback channels	0.713			0.553
Service expertise	0.703			0.648
Service Personalization	0.726			0.625
Timeliness of service	0.681			0.544

Based on the Likert scale analysis, the overall mean value is 3.95, indicating a relatively high level of satisfaction among users with the library study space at Zhuhai Institute of Science and Technology. However, there remains room for improvement as users hold higher expectations. The mean scores for each factor evaluation are as follows: supporting facilities and services scored 4.10, physical space scored 4.00, information resources scored 3.86, and psychological environment scored 3.72. This highlights user satisfaction with the library's supporting facilities and services, while indicating the need for enhancement in the psychological environment.

Within the Supporting Facilities and Services factor, the mean score for library opening hours is notably high at 4.21, suggesting users find the operating hours reasonable and conducive to meeting their study needs. However, the lowest evaluation score within this factor is 3.95 for the number of space facilities, indicating users perceive a deficiency in facilities such as tables, chairs, compartments, storage cabinets, lounge sofas, and guiding signs within the space. Regarding the Psychological Environment factor, the highest score is 3.82 for the sense of domain, while the lowest is 3.61 for the learning atmosphere. Insights from random on-site interviews reveal a preference among many users for the study space on the fifth floor of the library, particularly due to the provision of single tables with partitions. Users perceive these arrangements as facilitating personal space and aiding concentration in studies. However, some users have reported instances of seat occupation, gaming, movie watching, and disruptive noise, which undermine the conducive study environment and represent a misuse of the study space provided by the school library.

4.4 Regression Analysis

Stepwise regression, a method commonly employed in multivariate regression analysis, is a favored approach in data research modeling. This method iteratively introduces variables until no additional variables significantly contribute, ensuring the final set of

explanatory variables is optimal and succinct [16]. Consequently, a stepwise regression analysis will be conducted, with 21 research items as the independent variables and users' overall satisfaction with library learning spaces as the dependent variable. The process aims to identify the most influential factors on satisfaction among the 21 independent variables, thereby achieving the research objective. The results are presented in Table 4.

The findings are as follows:

① The model's R-squared value is 0.421, indicating that these variables account for 42.1% of the variance in satisfaction.

② The model passes the F-test (F (7,316)=32.817, p=0.000<0.05), confirming its validity. Additionally, assessment for multicollinearity within the model reveals all variance inflation factor (VIF) values to be below 5, suggesting the absence of collinearity issues and thus the model's reliability.

③ The model equation is as follows: Overall user satisfaction = 0.026 + 0.090space design + 0.154space capacity + 0.114color ambiance + 0.162online reservation + 0.159satisfaction with digital resources + 0.176service professionalism + 0.116*service timeliness.

④ The insignificance of spatial design (p>0.05) indicates its negligible impact on satisfaction. Conversely, significance (p<0.05) is observed for space capacity, color ambiance, online reservation, satisfaction with digital resources, service professionalism, and service timeliness, all of which have positive regression coefficients (B values), signifying a significant positive impact on satisfaction.

Table 4. Results of stepwise regression analysis (n=324)

regression model	Non-standardized coefficient		Standardized coefficient	*t*	*p*	covariance diagnosis VIF
	Bias regression coefficient *B*	standard error	Beta			
a constant (math.)	0.026	0.268	-	0.098	0.922	-
spatial design	0.090	0.052	0.095	1.747	0.082	1.618
space capacity	0.154	0.054	0.151	2.825	0.005**	1.555
color atmosphere	0.114	0.043	0.136	2.678	0.008**	1.402
Online Appointment	0.162	0.050	0.173	3.241	0.001**	1.560
Satisfaction with digital resources	0.159	0.050	0.164	3.172	0.002**	1.465
Service expertise	0.176	0.057	0.160	3.088	0.002**	1.466
Timeliness of service	0.116	0.049	0.117	2.371	0.018*	1.320
R^2			0.421			

regression model	Non-standardized coefficient		Standardized coefficient	*t*	*p*	covariance diagnosis VIF
	Bias regression coefficient *B*	standard error	Beta			
Adjustment R^2			0.408			
F			*F* (7,316)=32.817, p=0.000			

Note: Dependent variable: overall satisfaction; D-W value:1.808; * p<0.05 ** p<0.01.

5 Optimization Recommendations for Enhancing Library Learning Spaces Based on Post-Use Evaluations

Through stepwise regression analysis, it has been determined that space capacity, color ambiance, online booking systems, satisfaction with digital resources, service professionalism, and timeliness collectively account for 42.1% of the variance in overall user satisfaction, highlighting their significance in improving the satisfaction levels of college library study spaces.

5.1 Enhanced Spatial Layout Planning to Augment Diversity and Accessibility

The significant positive impact of space capacity on satisfaction underscores the importance of providing diverse and ample space through rational planning and layout. Library study spaces, categorized into personal, group, and leisure spaces, necessitate optimization in three dimensions: (1) Integration of functionally similar spaces to enhance the proportion of personal study spaces and overall space utilization. Research suggests a preference for individually partitioned study tables in open areas, advocating for a spectrum of personal study spaces ranging from fully private to semi-open. (2) Flexible arrangement of group study spaces, including fixed installations, designated rooms, or study corridors, while ensuring adequate isolation from personal study areas, possibly through the use of glass doors or noise reduction devices. (3) Appropriately designated leisure spaces, such as exhibition areas, study corridors, cafes, and lounges, to provide users with a relaxed and conducive atmosphere for informal interactions and heightened learning efficiency.

5.2 Attention to Space Color Coordination for Psychological Comfort

Environmental psychology research underscores the influence of color on users' senses[17], emotions, and efficiency. Therefore, creating a comfortable psychological environment entails: (1) Maintaining soft, neutral color tones in quiet areas like personal study spaces to foster calmness and concentration, while employing vibrant colors in communication areas to stimulate positivity and energy. (2) Artfully arranging

furniture and equipment to guide users' study behaviors and reflect the university's style and characteristics. (3) Introducing diverse indoor greenery, decorative elements, and color schemes to enrich the library's ambiance and elevate user satisfaction.

5.3 Optimization of Digital Resource Provision for Convenience and Accessibility

Strategic expansion of digital resources is pivotal for enhancing user satisfaction, encompassing: (1) Diversification and sharing of Chinese and foreign language databases, trial databases, and open databases, alongside regular updates to content and quantity. (2) Adherence to principles of clarity, diversity, and service orientation to maximize the effective utilization of electronic resources, potentially through partnerships with provincial libraries or sister institutions to bolster resource sharing platforms. (3) Provision of hardware facilities and specialized software for searching, information retrieval, and online learning, complemented by online reservation functionalities for user convenience.

5.4 Strengthening Service System Development with Emphasis on Professionalism and Timeliness

As service offerings expand, staff professionalism and timeliness become paramount. Strategies include: (1) Regular professional training and education for librarians, coupled with collaborations with experts from other institutions to elevate service quality. (2) Integration of various learning support services, such as reference consultations and subject-specific assistance, into the user experience to meet diverse needs[18]. (3) Innovative service approaches to engage students actively, including organizing lectures, book salons, and exhibitions to foster interdisciplinary learning and practical skill development.

6 Conclusion

This study, conducted through questionnaires and interviews, delved into the post-use evaluation of university library study spaces, focusing on users' sensory experiences. It identified space capacity, color ambiance, online booking systems, satisfaction with digital resources, service professionalism, and timeliness as the key factors influencing overall user satisfaction. Recommendations for optimization were proposed from four perspectives: physical space, psychological environment, information resources, and supporting facilities and services. Nevertheless, limitations in manpower and time were acknowledged, indicating the need for future research to refine indicators for specific spaces and expand data samples. By prioritizing users' experiences, this paper aimed to explore strategies and approaches for enhancing satisfaction with university library study spaces, with the hope of offering insights for similar construction projects in the future.

References

1. Feng, Ya, Li, Gang. Rediscovery of Non-traditional Learning and Spatial Value: A Review of Research on "University Library Learning Spaces" at Home and Abroad[J]. Journal of Agricultural Library and Information Science, 2020, 32(06): 4-14.
2. Oblinger, D.G. (2012) Learning Space
3. Beagle D .Conceptualizing an Information Commons[J].The Journal of Academic Librarianship, 1999, 25(2):82-89.
4. Creth, S. D. The Information Arcade: Playground for the Mind[J]. Journal of Academic Librarianship, 1994, 20(1): 22-24.
5. Huo, Jianmei, Luo, Yahong. Exploration of Extended Services in Physical Spaces of Foreign University Libraries: Based on a Survey of 20 University Libraries[J]. Library, 2022, (04): 89-95.
6. Cheng, Qian, Zhang, Kai, Fan, Wenyi, et al. Evaluation of Library Space Reconstruction in Universities: A Comparative Study of Learning Spaces in Two University Libraries[J]. Architectural Journal, 2022, No.26(S2): 208-214.
7. You, Kaikeng. Research on the Construction and Service of Learning Spaces in University Libraries under Virtual Reality Technology[J]. Library Work and Research, 2020, (09): 52-57.
8. Zhang, Xiaoyan. Thoughts on the Construction of Dynamic Learning Spaces in University Libraries Based on VR[J]. Information Recording Materials, 2021, 22(06): 47-49.
9. Song, Haiyan. Research on the Service Model and Dynamic Mechanism of Library Discipline Services in an Ubiquitous Knowledge Environment: An Exploration Based on Learning Space Integration Services[J]. Information Theory and Practice, 2010, 33(07): 58-62.
10. Zheng, Wenhui. Research on the Construction Model of Learning Spaces in University Libraries: Taking "211" University Libraries as an Example[J]. Library Research, 2020, 50(04): 59-64.
11. Zhou, Jianing, Feng, Na. Research on the Construction of Discipline-based Learning Commons: Taking the Economics and Management Branch of Sun Yat-sen University Library as an Example[J]. Journal of Academic Library and Information Science, 2018, 36(02): 53-56+101.
12. Liu, Jiajia, Han, Weihong, Chen, Jinghui. Research on Learning Commons Services in University Libraries: Taking the University of Iowa Library as an Example[J]. China Management Informatization, 2017, 20(23): 162-164.
13. Yu, Guiyan. Research on the Construction of Learning Commons in University Libraries: Taking Hebei University of Engineering Library as an Example[J]. Inner Mongolia Science Technology & Economy, 2014, (21): 65-66.
14. Wang, Mengyao, Xie, Yibin, Gao, Junhan. Analysis of Fear of Victimization in Urban Park Spaces Based on CPTED Concept: Taking Zijingshan Park in Zhengzhou as an Example[J]. Forestry Survey and Planning, 2022, 47(01): 161-166
15. Wang, Mengyao, Yang, Fangrong, Ding, Qinqin, et al. Exploring Fear of Victimization in University Campus Spaces Based on CPTED Theory: Taking Henan Agricultural University as an Example[J]. Journal of Qingdao University of Technology, 2022, 43(03): 93-100.
16. You, Shibing, Yan, Yan. Stepwise Regression Analysis Method and Its Application[J]. Statistics and Decision, 2017, (14): 31-35.
17. Shi, Ping, He, Qiang. Application and Research of Environmental Psychology in Interior Design[J]. Shanxi Architecture, 2009, 35(22): 31-33.

18. Li, Chen, Hu, Yuanyuan. Empirical Research on the Evaluation of Learning Spaces in University Libraries Based on User Experience[J]. Journal of Anhui University of Technology, 2019, 34(04): 75-8