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Research on Optimal Design of Campus Space Based on POE Concept: A Case Study of Anhui Xinhua College

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Abstract Through the analysis of the overall landscape, revetments and roads and plant landscape, 10 evaluation factors were determined. The comprehensive evaluation model for the campus space of Anhui Xinhua University was constructed by analytic hierarchy process (AHP). The results showed that revetment safety, road convenience, plant disease resistance and campus activity space were important factors affecting the spatial form planning of campus. Through the comparative analysis of the collected data, optimization suggestions were put forward to provide a basis for the establishment of "people-oriented" campus open space system.

Keywords Post occupancy evaluation, Analytic hierarchy process method, Campus, Space optimization

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POE refers to the research that designers grasp users' needs and systematically evaluate the designs that have been put into use[1-2]. As early as 1950s, the research on POE has been systematized, mainly used in buildings or service facilities. Alexander, Claire and others took the lead in discussing campus space and put forward relevant design ideas for open space[3]. Zhang and Wan[4] used GIS to analyze the relationship between user behavior trajectory and campus space design. Zhang et al.[5] calculated the efficiency of space use by studying the relationship between landscape richness and behavior. Zeng et al.[6] studied the outdoor open space of Jingyuan in Peking University from point to plane. At present, the research on campus space evaluation at home and abroad has reached a certain depth, but the space optimization measures are slightly insufficient, and no unified standard has been formed.

In this study, the problems and shortcomings of campus landscape space were deeply analyzed, aiming to provide strong theoretical support and practical guidance for the design and construction of campus landscape space in similar universities in the future.

1 General situation of Anhui Xinhua University

Anhui Xinhua University, adjacent to Dashushan Forest Scenic Area, has beautiful campus scenery such as Ruqin Lake, which is the school's largest viewing spot and the preferred tourist destination for teachers and students. The south and west of the school are accommodation areas, the sports area is located on the east side of the school, and the teaching area is located in the north and middle of the school, interspersed with a sports area and a dining area. The overall spatial layout is reasonable, meeting the needs of holding various campus activities and student exchanges. The public infrastructure is relatively complete, and the primary and secondary roads are clear. The campus has an elegant environment with lush flowers and trees, and there are good landscape material conditions.

2 Establishment and evaluation process of evaluation system based on AHP

2.1 Constructing a comprehensive evaluation model

According to the investigation results of Anhui Xinhua University, 10 evaluation factors were selected from three aspects: overall landscape, revetments and roads, and plant landscape, to comprehensively evaluate the campus space of Anhui Xinhua University. On the basis of consulting relevant literature, a comprehensive evaluation model was constructed taking comprehensive evaluation of Anhui Xinhua University as the target hierarchy A, overall landscape, revetment and roads and plant landscape as the constraint hierarchy C, and 10 evaluation factors including landscape richness and open space as specific evaluation indicators (Table 1). Subsequently, the paired comparison method and 1-9 scale marking were used to construct a judgment matrix[7], and the index weight value (w) was calculated, and the consistency of the judgment matrix was checked. Then, through weighting calculation, the total ranking weight values were obtained.

2.2 Formulation of scoring standards and comprehensive evaluation

In the process of questionnaire distribution, considering the objectivity of data, people of different genders and ages were invited for investigation. After the questionnaires were collected, the basic information was collated according to different age stages and gender, and the data was sorted and analyzed by various methods (Table 2).

2.3 Construction of judgment matrix and consistency test

In the evaluation process, six experts in related fields and 15 ordinary people in related fields were selected to compare the three factors in the constraint hierarchy and 10 factors in the index hierarchy by 1-9 scale marking method (1: equally important, 3: slightly important, 5: quite important, 7: strongly important, 9: absolutely important)[8], and a matrix model was obtained.

In order to reduce the subjective judgment error when the judgment matrix was artificially scored, the reliability of the matrix should be tested. When the maximum eigenvalue λ_{max} is closer to 1, that is, when the value

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$CI=(\lambda_{max}-n)/(n-1)$ is smaller, the matrix structure is more reasonable and the data consistency is stronger[9]. The specific calculation formulas are shown in Table 3.

Subsequently, it was required to judge the order of the matrix and search the average random consistency index *RI* that matched the decision analysis method used (Table 4).

Meanwhile, serving as the consistency ratio ($CR=CI/RI$), if $CR<0.10$, it could be judged that the weight distribution of various indexes was reasonable, which meant the matrix passed the consistency test. It can be seen from Table 5 that the consistency ratio (*CR*) of each matrix was lower than 0.10, which met the requirements of consistency test and the results were reasonable.

2.4 Calculation of overall ranking weights

The overall ranking weight refers to the specific numerical value of the relative importance of all factors within the same hierarchy relative to the highest hierarchy object[10]. As can be seen from Table 6, in the rule hierarchy, the relative weight of the overall landscape was the largest, indicating that overall landscape had the greatest influence on the space construction in the campus space construction; in the basic index hierarchy, the evaluation factors with top three weight values were P_4 revetment safety (0.266 7), P_5 road convenience (0.133 4) and P_9 disease resistance (0.120 1), showing that these three indexes had the greatest influence on the evaluation system, and two of them were located under the constrained hierarchy revetments and roads, which further illustrated the importance of revetments and roads to space construction; and P_2 landscape richness (0.059 4), P_1 beautiful environment (0.032 7) and P_6 seasonal variation (0.033 2) ranked in the last three in the index hierarchy, and had the least influence in the evaluation system.

Table 1 Comprehensive landscape evaluation model of Anhui Xinhua University

Object hierarchy (A)	Constraint hierarchy (C)	Index hierarchy (P)	Project hierarchy (D)
Comprehensive evaluation of Anhui Xinhua University (A)	Overall landscape (C_1)	Beautiful environment (P_1), Landscape richness (P_2), activity space (P_3)	Anhui Xinhua University to be evaluated (D)
	Revetment and roads (C_2)	Hydrophilicity of revetment (P_4), road convenience (P_5)	
	Plant landscape (C_3)	Plant ornamental value (P_6), seasonal variation (P_7), species richness (P_8), shading ability (P_9), disease resistance (P_{10})	

Table 2 Evaluation standards of evaluation factors

Evaluating indicators	Score		
	3	2	1
Beautiful environment	Pleasant scenery	Few viewing spots	Poor environment
Landscape richness	Rich landscape	General landscape	Poor landscape
Activity space	Plenty of room for activity	General activity	Less activity space
Revetment safety	Stable revetment structure	Slightly poor revetment structure	Serious security risks
Road convenience	Clearly divided road system	Generally divided road system	Mixed road system
Plant ornamental value	High ornamental value	General ornamental value	Low ornamental value
Seasonal variation	Abundant seasonal changes	General seasonal changes	Single plant color configuration
Species richness	Many varieties of plants	General application of plant varieties	Few varieties of plants
Shading ability	Many leaves, strong shading	General shading	Weak shading
Disease resistance	Strong resistance to adversity	Strong, capable of recovering after adversity	Vulnerable to adversity

Table 3 Calculation formula

No.	Item	Formula
1	Calculation formula of importance value	$a_{ij}=h_i-h_j+1(h_i>h_j)$ $a_{ij}=1(h_i=h_j)$ $a_{ij}=1/(h_j-h_i+1)(h_i<h_j)$
2	Multiplication for each row of judgment matrix	$a_i=\prod_{j=1}^{n}a_{ij}$
3	Resolving the nth root to get eigenvector bi	$b_i=\left(\prod_{j=1}^{n}a_{ij}\right)^{\frac{1}{n}}$
4	Normalizing bi to calculate the index weight vector	$w_i=\frac{b_i}{\sum b_i}$
5	Resolving the maximum eigenvalue	$\lambda_{max}=\frac{1}{n}\sum_i\frac{Aw_i}{w_i}$
6	Testing with consistency Index	$CI=\frac{\lambda_{max}-n}{n-1}$

Table 4 Reference of RI value

n order	3	4	5	6	7	8	9	10	11
RI value	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

3 Conclusions and Discussion

According to the evaluation factors, the secondary evaluation factors were divided into 10 items, in which overall landscape included three secondary factors, revetments and roads included two secondary factors, and plant landscape included five secondary factors. In general, the revetment safety of Anhui Xinhua University was highly valued by users, and its weight for the overall comprehensive evaluation was the highest, reaching 26.67%, and the weight of road convenience ranked second. According to the report, the space road system on campus is mixed, resulting in low convenience, which is especially serious in the green road system opposite the Zhongkuai canteen. In terms of design, they blindly pursue the aesthetic feeling of roads while ignoring the accessibility. Moreover, with the popularity of bike sharing on campus, the problem of narrow roads in some areas of campus, such as the academic lecture hall and Xiaowanda, has caused pressure on traffic. In view of this, we should attach importance to road planning, and scientifically and reasonably divide sidewalks and carriageways to ensure smooth traffic. In areas where people meet frequently, sidewalks must be appropriately widened to improve pedestrians' experience and improve the quality of traffic services. Furthermore, the excessive throwing of foreign objects in Ruqin Lake leads to the crazy growth of some aquatic algae, which makes the lake green with foul smell, and there is garbage floating everywhere on the lake, which reduces the sense of viewing experience. This kind of phenomenon also needs to be solved urgently, and the daily management and maintenance of Ruqin Lake should be strengthened.

In terms of overall landscape facilities, the facilities on campus, including seats and street lights, are aging and flaking paint, and other damages also appear. Some facilities have even become decorations and do not have actual functions. Most of existing seats are directly exposed to the sun, and they are closely arranged

with each other, leading to limitations in the use of facilities. In the follow-up design, in terms of seat setting, some sheltered seat areas should be appropriately added to provide more privacy and security. In featured landscape design, we can consider adding elements that reflect Hefei's cultural characteristics, such as sculptures and murals, to enhance the cultural experience and attraction of the campus. Secondly, some activity venues lack monitoring facilities, which leads to insufficient ability to prevent accidents. In order to improve the security of campus, it is necessary to strengthen the inspection and maintenance of monitoring equipment to ensure its normal operation, and expand the monitoring coverage to prevent and better deal with incidents. In addition, it is also found that many campus activity venues are only single spaces, which are only connected with other spaces by secondary and tertiary roads, so there is a lack of transition space. For example, from the library to Ruqin Lake, many venues are just a whole piece of flat land, and there is no topographic fluctuation, and the space is monotonous and has no visual focus after entering, which cannot make applicable people stay for a long time. In the future design, we should pay attention to improving the functionality of the site, note the transition between spaces, and build composite spaces[11], which can not only meet the needs of activities, but also satisfy the needs of rest and communication, and enhance the diversity of spaces. In terms of parking space, some teachers think that the design of parking space did not take into account many factors such as the actual number of parking spaces, the size of parking spaces, the width of traffic roads and the layout of parking lots.

In terms of plant landscape, the campus has a good ecological foundation, and users are satisfied with existing plant community in the open space of Anhui Xinhua University. The situation in which green trees are dominant has been improved, but the use of colored-leaf trees and flowering shrubs is still insufficient, and ginkgo, *Acer palmatum* and other plants are dominant, lacking zonal characteristics. In order to meet the psychological needs of users, it is still necessary to adopt the principle of "matching site with trees"[12] to improve the ecological conditions of the campus. Specifically, adding more kinds of plants around the space, considering adding some ornamental and interesting plants, planting plants in different regions and paying attention to the matching of plants in groups and according to seasons may be appropriate. Plant arrangement and plant layout should be expanded towards rationality, so as to improve users' viewing experience and satisfaction of psychological needs.

To sum up, through the overall index system of the open space in Anhui Xinhua University, this paper analyzed the main characteristics and existing problems of the space, and then further optimized and transformed the road system, landscape space and plant design to enhance the attraction and vitality of the campus, providing reference for the redesign of the open space of the campus today.

Table 5 Construction of judgment matrix structure and its consistency test

Hierarchical model	Judgment matrix						Relative weight (W)	Consistency test
A−C		C_1	C_2	C_3				
	C_1 Overall landscape	1	1	1/2			0.400	λ_{max}=3.010
	C_2 Revetments and roads	1	1	1/2			0.200	*CI*=0.005
	C_3 Plant landscape	2	2	1			0.400	*CR*=0.009<0.10
C_1−P		P_1	P_2	P_3				
	P_1 Plant landscape	1	1/2	1/3			0.163	λ_{max}=3.009
	P_2 Landscape richness	2	1	1/2			0.297	*CI*=0.005
	P_3 Activity space	3	2	1			0.540	*CR*=0.009<0.10
C_2−P		P_4	P_5					
	P_4 Revetment safety	1	1/3				0.249	λ_{max}=2.000
	P_5 Road convenience	3	1				0.750	*CI*=0
								CR=0<0.10
C_3−P		P_5	P_6	P_7	P_8	P_9		
	P_5 Plant ornamental value	1	1/2	1/4	1/3	1/2	0.083	λ_{max}=5.378
	P_6 Seasonal variation	2	1	1	1	1/3	0.168	*CI*=0.094
	P_7 Species richness	4	1	1	1/2	1/2	0.179	*CR*=0.084<0.10
	P_8 Shading ability	3	1	2	1	2	0.300	
	P_9 Disease resistance	2	1/3	2	1/2	1	0.269	

Table 6 Ranking of evaluation factor weights

Hierarchy A	Hierarchy C	W	Hierarchy P	W	Total ranking weight	Rank
A	C1	0.400	P_1	0.163	0.032 7	9
			P_2	0.297	0.059 4	8
			P_3	0.540	0.107 9	4
	C2	0.200	P_4	0.249	0.266 7	1
			P_5	0.750	0.133 4	2
	C3	0.400	P_6	0.083	0.033 2	10
			P_7	0.168	0.067 2	7
			P_8	0.179	0.071 7	6
			P_9	0.300	0.120 1	3
			P_{10}	0.269	0.107 7	5

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nodes and the restoration of ecological environment, which has promoted the urban renewal and development and formed a development model of smart growth and resilient growth. In three years, the Xishui River ecological government project has become the main effective means for the great changes in this county, which has gradually realized the transformation of urbanization and modernization throughout Xishui County, providing residents and tourists with a better housing, living and tourism environment.

4 Conclusions and Discussion

Urban renewal is an important way to improve urban quality. It should follow the law of urban development and the principle of organic renewal, and comprehensively consider various aspects including protection, renovation, reconstruction, development and utilization. The design of urban quality improvement in the stock era needs to consider such factors as multiple demands, urban capacity reduction, integration of old and new, humanistic care and green innovation. In practice, we can adopt such strategies as compounding, localization, people-oriented and intelligent management. Meanwhile, the concept of sustainable development is implemented in the whole process, so as to create a comprehensive urban revival and realize the integration of society, culture, economy and material space.

The organic renewal project of Linping Old City mentioned in this study fills the gap of cultural service facilities in the old city by constructing a new urban spatial pattern of "one mountain, one water, one corridor" and provides a national model for the organic renewal of old cities by applying intelligent community management. The Xishui River ecological government project brought the waterfront space back into the growth and development system of the whole city by constructing a new landscape pattern of "one axis, two centers, six areas", which has promoted the urban renewal and development and formed a development model of smart growth and resilient growth.

The research on design strategies and practical paths for urban quality improvement in the stock era can help urban planning to shift from paying attention to new investment to paying more attention to the rational utilization and upgrading of existing urban resources, which is a necessary measure to adapt to the current urban development situation and promote urban sustainable development. Meanwhile, this study emphasized the principle of organic renewal, paying attention to multiple and complex needs, and promoting the importance of intelligence and greening, and put forward that new urban planning concepts and technical means can be explored to promote more accurate, efficient and sustainable development of urban renewal.

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