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AHP-based Quality Evaluation of Temporary Museum Exhibitions: A Case Study of "The Exhibition of the Jinxiang County Princess in the Tang Dynasty"

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Abstract: Temporary exhibitions are essential for revitalizing museums and maintaining their appeal to the public. This study takes the "The Exhibition of the Jinxiang County Princess in the Tang Dynasty", organized by the Xi'an Museum, as a case study to quantitatively evaluate the exhibition quality. The results show that, in the criteria layer, the scores are ranked as follows: exhibition resources (B1), exhibition design (B2), exhibition extension (B3), and exhibition services (B4), from highest to lowest. Additionally, the study analyzes the reasons behind the lower scores in certain factors and reference layers. This evaluation aims to identify issues within temporary exhibitions and provide scientific insights for improving the overall quality of exhibition displays in museums.

Keywords: Temporary Exhibitions; AHP Method; "The Exhibition of the Jinxiang County Princess in the Tang Dynasty"; Exhibition Quality; Evaluation.

1. Introduction

A museum serves as a "window" through which the history, culture, and modern civilization of a region or even a country are displayed. Exhibitions are the core medium through which a museum fulfills its role in cultural dissemination and preservation. In the museum community, long-term, relatively stable display projects are referred to as permanent displays, while short-term, frequently changing displays are termed exhibitions or temporary exhibitions[1]. Compared to permanent displays, temporary exhibitions are more timely and diverse, effectively enriching the museum's content and enhancing the audience's experience[2]. Quantitative evaluation of the quality of temporary exhibitions aims to identify issues within the exhibitions, improve the overall level of museum displays, and contribute to the prosperity and development of the museum sector. The assessment of exhibition quality involves both expert judgment and audience evaluation, forming a dual evaluation system[3]. A successful exhibition must meet the criteria of both evaluations[4]. The tomb of the Jinxiang County Princess in Tang Dynasty was discovered in 1991 in the Baqiao district of Xi'an, uncovering 181 pieces (or sets) of artifacts representing the peak of the Tang Dynasty. In 2022, marking the 30th anniversary of the archaeological discovery of the tomb, the Xi'an Museum organized the "The Exhibition of the Jinxiang County Princess in the Tang Dynasty". By using the AHP method to quantitatively evaluate the exhibition quality of "The Exhibition of the Jinxiang County Princess in the Tang Dynasty", this study can effectively assess the exhibition's performance, identify existing problems and their causes, and provide scientific references for the future enhancement of museum exhibitions.

2. Overview of the Exhibition Design for "The Exhibition of the Jinxiang County Princess in the Tang Dynasty"

"The Exhibition of the Jinxiang County Princess in the Tang Dynasty" is structured around a temporal order, drawing on archaeological discoveries and research findings to narrate the illustrious life of the Princess of Jinxiang. The exhibition is divided into four sections: "The County Princess in Tang Dynasty", "Born in a Glorious Era", "A Colorful Life", and "Harmony in Union".

The first section, "The County Princess in

Tang Dynasty", introduces the excavation and overview of the Jinxiang County Princess's tomb. The second section, "Born in a Glorious Era", comprehensively illustrates the prosperous epoch in which the princess lived. The third section, "A Colorful Life", offers a multi-dimensional portrayal of her daily life. The fourth section, "Harmony in Union", presents the harmonious life the princess shared with her husband.

The museum's exhibition design represents a secondary creation and enhancement of the exhibit's content. It organizes and presents selected artifacts according to specific themes, requirements, and goals, following a logical and ordered approach within the exhibition space. It is a fusion of artifacts, text, and spatial design. In the transmission of exhibition information, the exhibition text serves as the most efficient tool for interpreting the artifacts. "The Exhibition of the Jinxiang County Princess in the Tang Dynasty" employs concise and precise text to convey artifact information comprehensively, effectively avoiding visual clutter caused by excessive text. The use of balanced light and dark tones enhances the internal exhibition environment, enriching the visual impact and delineating the exhibition's different layers. The exhibition adopts a low-saturation color palette, creating a soft, elegant atmosphere that emphasizes the refined aesthetic of the design. In terms of spatial design, the architectural exterior of the exhibition hall is shaped to reflect the exhibition space, with a surrounding design of illustrated panels on the upper part of the exterior façade. Inside, the decor follows a minimalist, fashionable artistic expression, embodying the grandeur and elegance of the Tang Dynasty. As a medium of communication and display, multimedia aids visitors in more intuitively and vividly understanding the representation and significance of the exhibited objects. It enhances the fundamental exhibition information. For instance, in the first section, "Discovery of the County Princess", a wall-mounted archaeological model of the tomb presents a three-dimensional display of the tomb's structure, including the passageway, antechamber, courtyard, and burial chamber, while also restoring and showcasing precious artifacts that are missing or damaged.

Furthermore, "The Exhibition of the Jinxiang County Princess in the Tang Dynasty" incorporates virtual exhibitions, live streaming, and online guided tours. Through academic discussions, themed educational activities, and cultural and creative design, it transcends the physical boundaries of the exhibition, extending its content and enhancing interaction with visitors. This approach transforms the viewing experience from "being present" to "being virtually engaged", allowing audiences to delve deeper into the exhibition.

3. Museum Exhibition Quality Evaluation System and Process Based on AHP Method

3.1 Establishment of the Museum Exhibition Evaluation System

3.1.1 Identification of evaluation participants

The participants in the evaluation process can be broadly categorized into two groups: The first group consists of museum experts, scholars, and practitioners with substantial theoretical expertise and practical experience in exhibition design, architectural design, and art design, including professionals from museums, universities, research institutes, design firms, as well as students and volunteers in museum studies and related fields. The evaluation results from this group form the primary basis for this evaluation system. The second group includes individuals unrelated to the museum field (such as students and members of the general public), whose feedback through questionnaires and interviews will serve as supplementary reference for the evaluation system.

3.1.2 Selection of evaluation indicators

The selection of evaluation indicators must be comprehensive, reflecting all factors that influence the quality of museum exhibitions. The indicators should objectively and scientifically present the exhibition’s quality requirements and the methods of achieving these standards.

3.1.3 Development of the evaluation model

The process involves identifying the key factors involved in the decision-making process and categorizing these factors based on goals, criteria, measures (plans, methods), etc., to construct a hierarchical model that reflects the relationships and dependencies between the factors. Based on the overall objective of the evaluation, the model is divided into four layers: Goal Layer A, Criteria

Layer B including indicators B1, B2, ..., Bn, Factor Layer C including indicators C1, C2, ..., Cn, and Reference Layer D including indicators D1, D2, ..., Dn.

3.2 Museum Exhibition Quality Evaluation Process

3.2.1 Constructing the judgment matrix

In order to derive the judgment matrix through pairwise comparisons among factors, it is necessary to quantify these comparisons. The calculation of the eigenvector of the judgment matrix is the core of the AHP method. After establishing a hierarchical structure, the indicators or factors at each level are compared in pairs based on the 1-9 importance scale proposed by Professor Saaty (see Table 1). The importance of each factor is quantified using numerical values, which then forms the mathematical judgment matrix[5].

Table 1. 1-9 Comparison Scale

Bij Value	1	3	5	7	9	2, 4, 6, 8	Reciprocal of the Above Values
Meaning	Elements bi and bj are equally important	bi is slightly more important than bj	bi is more important than bj	bi is significantly more important than bj	bi is extremely more important than bj	Intermediate values of the above comparisons	Reverse comparison, bij = 1/bij

3.2.2 Calculating the weight vector

The following steps and methods are used to calculate the weight of each indicator in the museum exhibition quality evaluation system using the AHP method:

(1) Compute the product of the elements in each row of the judgment matrix: $M_i = \prod_{j=1}^{n} a_{ij}$

(2) Take the n-th root of M_i to obtain the weight: $\overline{W_i} = \sqrt[n]{M_i}$

(3) Normalize the weight, W_i, which represents the percentage of each indicator relative to the upper-level indicators:

$$W_i = \frac{\overline{W_i}}{\sum_{i=0}^{n} \overline{W_i}} (i = 1,2,\cdots,n)$$

(4) Construct the normalized weight vector: $W = (W_1, W_2, \cdots, W_n)^T$

3.2.3 Performing consistency check

Conducting a consistency check on the judgment matrix is an essential step to ensure its rationality. This involves using consistency indicators, the random consistency index, and the consistency ratio. If the consistency check is passed, the eigenvector (normalized) becomes the weight vector. Otherwise, the comparison matrix must be revised.

The first step is to compute the maximum eigenvalue $\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i}$, where $(AW)_i$ represents the i-th component of the vector AW.

The consistency check is then conducted to assess the consistency strength of a matrix A, based on the average eigenvalue difference (CI), which serves as the consistency indicator. The decision rule is: $CI = \frac{\lambda_{max} - n}{n-1}$.

Generally, if CI≤0.1, the judgment matrix is considered consistent, proving that the weights calculated earlier are reasonable. However, as n increases, the judgment error also increases, so the effect of n must be considered during the consistency check. Therefore, a random consistency index (RI) is introduced (see Table 2), which involves randomly sampling from the numbers 1/9, 1/8, ..., 1, 2, ..., 9 to form the judgment matrix and calculating the average consistency index.

Usually, the consistency ratio CR=CI/RI is used to test the consistency of the judgment matrix. If CR≤0.1, the judgment matrix is considered to have satisfactory consistency. Otherwise, the matrix needs to be adjusted until satisfactory consistency is achieved.

Table 2. Random Consistency Index (RI) Table

Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.90	1.12	1.24	1.32	1.45	1.49

4. Empirical Study on the Exhibition Quality Evaluation of "The Exhibition of the Jinxiang County Princess in the Tang Dynasty"

4.1 Establishing the Indicator Hierarchy Model

Based on Porter's Diamond Theory and research related to the tomb of the Jinxing

County Princess, the evaluation factors are scientifically selected to construct a hierarchical model for the exhibition quality evaluation of "The Exhibition of the Jinxiang County Princess in the Tang Dynasty". The structure consists of four levels: Goal Layer A, Criteria Layer B, Factor Layer C, and Reference Layer D, encompassing 4 major criteria, 10 factors, and 29 reference elements (see Table 3).

Table 3. Exhibition Quality Evaluation Indicator System Model for "The Exhibition of the Jinxiang County Princess in the Tang Dynasty"

A"The Exhibition of the Jinxiang County Princess in the Tang Dynasty" Exhibition Quality Evaluation														
B1Exhibition Resources					B2 Exhibition Design									
Exhibit Selection C1		Exhibit Value C2			Content Design C3			Form Design C4						
Exhibit Quantity and Types D1	Exhibit Fame D2	Historical and Cultural ValueD3	Scientific, Educational Value D4	Artistic ValueD5	Clarity of Theme D6	Academic Rigor of Content D7	Readability of Text D8	Spatial Layout D9	Color Usage D10	Lighting D11	Design Integration D12	Layout D13	Technological Installations D14	
B3 Exhibition Extension							B4 Exhibition Services							
Digital Exhibition C5		Educational Activities C6		Live Lectures C7	Cultural and creative Design C8			Explanation Services C9				Guided Tour Services C10		
Exhibition Quality D15	Exhibition Traffic D16	Participant Engagement D17	Richness and Innovation D18	Lecture Audience Size D19	Balance of Academic and Fun Content D20	Use of Memes D21	Cost-Effectiveness of Cultural and creative Products D22	Purchase Rate of Cultural and creative Products D23	Affordability of Explanation Fees D24	Professionalism and Service Attitude D25	Usability and Convenience of Audio Guides D26	Knowledge and Fun in Content D27	Appropriateness of Guided Tour Manual Content D28	Completeness of Guidance Services D29

4.2 Construction of the Comparison Judgment Matrix

In accordance with the requirements of the AHP method, a questionnaire survey is conducted to invite evaluators to score the indicators of evaluation factors for which data cannot be directly obtained. The scoring range is from 1 to 10. Data such as exhibition views, the number of listeners for live lectures, and the purchase rate of offline cultural and creative products are collected from the curatorial units. After standardizing all the factor data, the average value of the scores is taken, and a judgment matrix for each level of indicators is established.

Taking the criteria layer B as an example, its judgment matrix is constructed (Table 4).

Table 4. The Judgment Matrix of Criteria Layer B for the Goal Layer A

Criterion layer	Exhibition resources B1	Exhibition design B2	Exhibition extension B3	Exhibition service B4
Exhibition resources B1	1	3	3	3
Exhibition design B2	1/3	1	3	2
Exhibition extension B3	1/3	1/3	1	2
Exhibition service B4	1/3	1/2	1/2	1

4.3 Weight Calculation and Consistency Check

After determining the judgment matrix, the factor weights are calculated, and a consistency check is performed. Taking criteria layer B as an example, the weight calculation and consistency check are conducted based on the judgment matrix of criteria layer B for the goal layer A (Table 4). The calculation process is as follows:

1. Calculate the product of the elements in each row of the matrix:

MB1=1*3*3*3=27; *MB2*=1/3*1*3*2=2;

MB3=1/3*1/3*1*2=0.22;

MB4=1/3*1/2*1/2*1=0.08.

2. Calculate the fourth root of M_i to obtain the weights:

$\overline{W_{B1}}=\sqrt[4]{27}$ =2.27; $\overline{W_{B2}}=\sqrt[4]{2}$ =1.18;

$\overline{W_{B3}}=\sqrt[4]{0.22}$ =0.68; $\overline{W_{B4}}=\sqrt[4]{0.08}$ =0.53;

3. Obtain the normalized weights for B1, B2, B3, and B4:

$W_{B1}=\overline{W_{B1}}/\overline{W_B}$ =2.27/(2.27+1.18+0.68+0.53)= 0.49;

$W_{B2}=\overline{W_{B2}}/\overline{W_B}$ =1.18/(2.27+1.18+0.68+0.53)= 0.25;

$W_{B3}=\overline{W_{B3}}/\overline{W_B}$ =0.68/(2.27+1.18+0.68+0.53)= 0.15.

$W_{B3}=\overline{W_{B3}}/\overline{W_B}$ =0.53/(2.27+1.18+0.68+0.53)= 0.11.

4. Calculate the weight vector:

AW_B≈[2.02,1.08,0.62,0.47]

On this basis, a consistency check is performed. The maximum eigenvalue is calculated:

λ_{max} =1/4*

$$\sum_{i=1}^{4}(2.02/0.49 + 1.08/0.25 + 0.62/0.15 + 0.47/0.11) = 4.23$$

The consistency index (CI) is obtained as 0.07, and the consistency ratio (CR) is 0.07, indicating that the judgment matrix for criteria layer B with respect to goal layer A meets the logical requirements, and the derived weight indicators are reliable.

Using the same method, the weights for other indicators are calculated based on the judgment matrices of other layers, yielding the "The Exhibition of the Jinxiang County Princess in the Tang Dynasty" exhibition quality evaluation indicators (Table 5). Additionally, through the CR consistency ratio check, it is found that all CR values are less than 0.1, indicating satisfactory consistency for the judgment matrices at all levels.

Table 5. Exhibition Quality Evaluation Indicator Weights for "The Exhibition of the Jinxiang County Princess in the Tang Dynasty"

Pointer code	B1	B2	B3	B4	-	-	-	-	-	-
W_i	0.49	0.25	0.15	0.11	-	-	-	-	-	-
Pointer code	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
W_i	0.56	0.44	0.53	0.47	0.18	0.41	0.29	0.12	0.42	0.58
Pointer code	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
W_i	0.57	0.43	0.59	0.16	0.25	0.54	0.30	0.16	0.27	0.12
Pointer code	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20
W_i	0.10	0.17	0.25	0.09	0.55	0.45	0.41	0.59	0.43	0.57
Pointer code	D21	D22	D23	D24	D25	D26	D27	D28	D29	-
W_i	0.53	0.33	0.14	0.55	0.27	0.11	0.07	0.63	0.37	-

Based on Table 4, the corresponding indicator weights and factor values in the "The Exhibition of the Jinxiang County Princess in the Tang Dynasty" exhibition quality evaluation system are substituted into the multiplicative model to calculate the evaluation values for each indicator (Table 6).

5. Analysis of Evaluation Results

The comprehensive evaluation score of the exhibition "The Exhibition of the Jinxiang County Princess in Tang dynasty" was 8.54 points, indicating that the exhibition has high quality and good response.

Exhibition resources are the core content of exhibition and the primary factor that determines the quality of exhibition and influences the effect of exhibition. Historical relics resources are the material and cultural heritages of historical, artistic and scientific value left by mankind in the course of historical development. In the comprehensive evaluation score of the exhibition, the evaluation score of the exhibition resources is the highest, 4.37 points. It can be seen that the cultural relics on display have very high historical and cultural value, artistic appreciation value and high scientific research and education value, and the number of cultural relics on display is large, rich types and high visibility.

The exhibition design score was 2.14 points, ranking second in the overall evaluation score of the exhibition, but the form design score was lower than the content design. Formal design is a creative activity that conveys the curator's thinking and imagination in visual form according to the contents of the exhibition text outline [6]. Excellent exhibition design can better highlight the exhibition theme, enrich the space environment, and enhance the exhibition effect [7]. In the design of exhibition form, the selection and layout of light sources, as well as the interactive design of the exhibition centered on scientific and technological devices such as multimedia technology and digital technology application, directly affect the display effect of the exhibition and the audience's experience [8]. The lighting and technology installations of this exhibition scored lower, 0.09 and 0.07 points respectively. Multimedia technology can not only restore the exhibited cultural relics to their historical environment, greatly expand the display connotation of cultural relics, and allow the audience to experience the exhibit information from the perspective of vision, hearing, touch and even smell [9]. The use effect is not good, which has a certain impact on the quality of the exhibition.

The exhibition extension score was 1.19 points, ranking third in the overall evaluation score of the exhibition. Among them, the scores of themed education activities and live lectures

are high, which shows that themed education activities are rich and innovative, and the content of live lectures is academic and interesting. However, the scores of the participation of themed activities and the number of listeners of live lectures are relatively low, indicating that the publicity of the exhibition is not in place, which affects the social heat and continuous discussion of the exhibition. The score of cultural and creative design is the lowest, and the quality and cost performance of the line are not high, resulting in a low purchase rate of the line.

The service object of a museum is the audience, and the fundamental purpose of a museum is to serve the audience and meet the needs of the audience [10]. The exhibition service is the key factor affecting the quality of the exhibition, but the score of the exhibition service of "The Exhibition of the Jinxiang County Princess in Tang dynasty" is 0.84 points, ranking the last in the comprehensive evaluation of the exhibition. Especially in the explanation service, the content of explanation is lack of knowledge and interest, and the use and convenience of voice explanation is not high, which affects the experience of visitors.

Table 6. Exhibition Quality Evaluation Values for "The Exhibition of the Jinxiang County Princess in the Tang Dynasty"

Target layer A	score	Criterion layer B	score	Factor layer C	score	Reference layer D	score
"The Exhibition of the Jinxiang County Princess in the Tang Dynasty" display quality evaluation A	8.54	Exhibition resources B1	4.37	Exhibit Selection C1	2.32	Number and type of exhibits D1	1.36
						Exhibit awareness D2	0.96
				Exhibit value C2	2.05	Historical and cultural value D3	1.12
						Value of scientific research and education D4	0.36
						Art viewing value D5	0.57
		Exhibition Design B2	2.14	Content Design C3	1.17	Topic clarity D6	0.23
						The content is academic D7	0.56
						Legibility of text D8	0.35
				Formal design C4	0.97	Space layout D9	0.28
						Color use D10	0.11
						Lighting D11	0.09
						Combined design D12	0.17
						Layout D13	0.25
						Technology device D14	0.07
		Exhibition Extension B3	1.19	Digital exhibition C5	0.23	Exhibition quality D15	0.13
						Exhibition views D16	0.10
				Educational activities C6	0.48	Participation in themed activities D17	0.19
						The richness and innovation of themed activities D18	0.29
				Live lecture C7	0.34	Number of listeners D19	0.14
						Academic and interesting content D20	0.20
				Cultural Design C8	0.14	The usage rate of emojis is D21	0.08
						The cost performance of cultural and creative D22	0.04
						The purchase rate of cultural and creative D23	0.02
		Exhibition Service B4	0.84	Explain service C9	0.34	Explain the affordability of the cost D24	0.19
						Professional level and service attitude D25	0.09
						The use and convenience of voice explanation D26	0.04
						Content of knowledge and interest D27	0.02
				Guided tour Service C10	0.50	The guide book is well detailed D28	0.32
						Boot service completeness D29	0.18

6. Conclusions

By using the analytic hierarchy process, we can scientifically judge the display effect of "The Exhibition of the Jinxiang County Princess in Tang dynasty". We can see that the exhibition has high quality and good response, but there are shortcomings in scientific and

technological devices, lighting, cultural and creative design, explanation services and other aspects. Through the evaluation of the exhibition quality of "The Exhibition of the Jinxiang County Princess in Tang dynasty", it provides a scientific basis for improving the display effect of this exhibition, and provides a certain reference for the display design of other exhibitions.

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