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# Research on Construction of Evaluation Index System for 3d Display Design of Revolutionary Cultural Relics

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## Abstract

**Design evaluation is an important means to improve the quality of design. In order to promote the display effect of the 3D model of revolutionary cultural relics, a set of design evaluation index system is established.**

## Keywords

**Evaluation index system, Design evaluation, 3D model display, Revolutionary cultural relics.**

## 1. Introduction

Revolutionary cultural relics are typically displayed using digital technologies such as Virtual Reality, Augmented Reality, and Digital Twins. The two primary forms of display are the "virtual exhibition hall display" and the "three-dimensional model display." The "virtual exhibition hall display" is particularly effective in digitally displaying revolutionary cultural relics due to its comprehensive content and authentic experience.

For instance, the Ningxia Museum has introduced a virtual exhibition hall called "Red Flag Rolling - Ningxia Revolutionary Cultural Relics Display," while the Chinese People's War of Resistance Against Japan Memorial Museum has launched a similar virtual exhibition hall called "Beacon Fire - Beijing Anti-Japanese War Theme Area Special Exhibition." Anhui Museum has also launched a digital exhibition hall called "Beacon Fire - Anhui Revolutionary History Display." On the other hand, the "three-dimensional model display" of revolutionary cultural relics has not been widely used due to the immaturity of its technology and supporting ecology.

As information technology continues to develop and progress, the functional modules of "3D model display" have greatly expanded. For example, audio and video playback, animation demonstration, interactive interaction, and other features have been added, significantly enhancing the display effect. On the other hand, the "3D model display" has gained renewed attention and favor from the industry due to its outstanding advantages such as being "lightweight[1]", "easy to spread," and "better adaptation to the modern, fast-paced life and new reading and browsing habits of the public." It has become one of the most crucial elements in the matrix of heritage communication.

A review of related research indicates that most existing studies on the 3D model display of cultural relics have focused on technology and development[2-3]. At the same time, design evaluation has yet to receive much attention. However, design evaluation is a crucial and indispensable aspect of design work, as it can assist designers in selecting design solutions and enhancing their quality. Therefore, research on the design evaluation of 3D model displays of cultural relics is of significant practical importance.

In order to further improve the quality and effect of the revolutionary cultural relics 3D model display design, this paper intends to analyze the critical factors in the revolutionary cultural relics 3D model display design and build a revolutionary cultural relics 3D model display design

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evaluation index system with design guidance from four aspects: content design, function design, interface design, and interaction design.

## 2. Evaluation index system construction

To construct the evaluation index system for the design of 3D model displays of revolutionary cultural relics, the Delphi Method and Analytic Hierarchy Process were used. The Delphi Method was employed to establish the design evaluation indexes, while the Analytic Hierarchy Process was utilized to calculate the index weights. The specific construction process is described as follows.

### 2.1. Preliminary construction of evaluation index system

We searched China Knowledge Network using keywords such as "revolutionary cultural relics," "3D model display", "3D display", "virtual display," "virtual museum," "digital museum," and "display design." We obtained 291 valid documents, including academic journals, master's theses, and conference papers.At the same time, we searched the global citation database Web of Science for the terms "Virtual Museum," "3D Display", "Three-dimensional Exhibition," and "Display Design." We obtained a total of 135 valid documents.

The literature was imported into Nvivo software for word frequency analysis, and the remaining words with high frequency included "interface," "interaction," "virtual," "model," "design," "information," etc., "model," "design," "information" and so on. On the one hand, considering the abstract meanings of the selected high-frequency words, and on the other hand, to avoid omitting essential words, the words counted by Nvivo software were further interpreted and supplemented by manual reading. The specific steps are as follows: (1) set up a research group (including three associate professors, two doctoral students, and six master students in related fields); (2) interpret and explain the vocabulary derived from Nvivo software; (3) dig up essential vocabulary not covered and add them, such as "experience" and "loading"; (4) conduct several group discussions, organize, classify and summarize the collected vocabulary, and establish a preliminary index system for evaluating the 3D model display design of revolutionary cultural relics, including 4 primary indicators, 12 secondary indicators, and 37 tertiary indicators.

### 2.2. Optimization and finalization of the indicator system

1)Development of consultation questionnaire

In order to further optimize and improve the evaluation indicators, a consultation questionnaire was prepared. Two explanations of the consultation questionnaire: First, a five-level Likert scale was used to measure the importance of the indicators, as shown in Table 1; second, a "subjective suggestions and opinions filling place[3]" was set in the consultation questionnaire, so that experts can add and modify the evaluation indicators.

**Table 1:** Five level Likert scale of importance

| Indicator Importance | Not important | Less important | General | More important | Extremely important |
|---|---|---|---|---|---|
| Scoring score | 1 | 2 | 3 | 4 | 5 |

2)Consulting Expert Selection

Experts in virtual museums, cultural relics display, and 3D model display are selected under "expert authority coefficient Cr≥0.70[4]". The expert authority factor Cr is determined by the judgment basis factor Ca and the familiarity factor Cs, and the formula is $Cr = (Ca + Cs)/2$. $Cr \in [0, 1]$. where a higher value of Cr indicates a higher authority of that expert.

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The specific calculation process and results of the expert authority coefficients are as follows: first, the judgment basis coefficient Ca scale, and the familiarity coefficient Cs scale were constructed as shown in Tables 2 and 3, respectively. Secondly, the experts were evaluated according to the two scales of judgment basis coefficient Ca and familiarity coefficient Cs, and the evaluation results are shown in Table 4. Finally, 15 experts were selected (all experts' authority coefficients Cr ≥ 0.75, which meets the selection conditions).

**Table 2:** Scale of Ca

| Judgment basis | Experts judge the extent of the impact | | |
|---|---|---|---|
| | Great | Middle | Little |
| Work Experience | 0.50 | 0.40 | 0.30 |
| Logical Reasoning | 0.30 | 0.20 | 0.10 |
| Industry Understanding | 0.10 | 0.10 | 0.10 |
| Intuitive Feeling | 0.10 | 0.10 | 0.10 |
| Total | 1.00 | 0.80 | 0.60 |

**Table 3:** Scale of Cs

| Familiarity level | Very unfamiliar | Less familiar | General | More familiar | Special familiarity |
|---|---|---|---|---|---|
| Familiarity factor | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 |

**Table 4:** Calculation results of Cr

| Number | Experts judge the extent of the impact | | | | Judgment basis factor (Ca) | Familiarity factor (Cs) | Expert Authority Factor (Cr) |
|---|---|---|---|---|---|---|---|
| | Work Experience | Logical Reasoning | Industry Understanding | Intuitive Feeling | | | |
| 1 | 0.50 | 0.20 | 0.10 | 0.10 | 0.90 | 0.75 | 0.825 |
| 2 | 0.40 | 0.30 | 0.10 | 0.10 | 0.90 | 1.00 | 0.950 |
| 3 | 0.40 | 0.20 | 0.10 | 0.10 | 0.80 | 1.00 | 0.900 |
| 4 | 0.50 | 0.30 | 0.10 | 0.10 | 1.00 | 0.75 | 0.875 |
| 5 | 0.40 | 0.30 | 0.10 | 0.10 | 0.90 | 1.00 | 0.950 |
| 6 | 0.50 | 0.30 | 0.10 | 0.10 | 1.00 | 0.75 | 0.875 |
| 7 | 0.50 | 0.20 | 0.10 | 0.10 | 0.90 | 1.00 | 0.950 |
| 8 | 0.40 | 0.30 | 0.10 | 0.10 | 0.90 | 0.75 | 0.825 |
| 9 | 0.50 | 0.30 | 0.10 | 0.10 | 1.00 | 1.00 | 1.000 |
| 10 | 0.50 | 0.20 | 0.10 | 0.10 | 0.90 | 0.75 | 0.800 |
| 11 | 0.50 | 0.30 | 0.10 | 0.10 | 1.00 | 0.50 | 0.750 |
| 12 | 0.40 | 0.30 | 0.10 | 0.10 | 0.90 | 1.00 | 0.950 |
| 13 | 0.50 | 0.30 | 0.10 | 0.10 | 1.00 | 0.75 | 0.875 |
| 14 | 0.50 | 0.30 | 0.10 | 0.10 | 1.00 | 1.00 | 1.000 |
| 15 | 0.50 | 0.20 | 0.10 | 0.10 | 0.90 | 1.00 | 0.950 |
| Mean value | 0.467 | 0.267 | 0.10 | 0.10 | 0.933 | 0.867 | 0.898 |

3)Round I Consultation Questionnaire Distribution and Collection

(1) The experts were asked to rate the importance of each index according to Table 1 and to indicate the indexes that need to be added or modified in the "Subjective Suggestions and Opinions" (15 questionnaires were collected in the first round, with a valid return rate of

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100%).(2) We collected the questionnaires from the first round of consultation and calculated the mean value of index importance. Among them, the importance of "alignment of interface layout" and "consistent spacing of fonts" were lower than 3.50[5], so they were excluded from the index system.(3) The consistency of experts' opinions was judged by the coefficient of variation C.V. Let be the importance rating of the ith expert on the jth index, and be the mean value of the jth importance rating by 15 experts, i=1,2,...,15; j=1,2,...,34, then the coefficient of variation $C.V_j$ of the jth item is calculated as

$$C.V_j = \sqrt{\frac{1}{15}\sum_{i=1}^{15}\left(w_{ij} - \overline{w}_j\right)^2} / \overline{w}_j \tag{1}$$

$$\overline{w}_j = \sum_{i=1}^{15} w_{ij} / 15 \tag{2}$$

The larger the C.V. value, the more significant the difference in expert opinions. Generally, a C.V value greater than 0.25[6] indicates that experts' opinions need to be unified, and the index cannot pass the consistency test. After calculation, the C.V value of the "scene can switch" indicator is 0.31, which is greater than 0.25 and fails the consistency test, so it is deleted.(4) According to the results of the consultation questionnaire, two tertiary indicators were added, namely "prevent users from misuse or easy to recover after misuse" and "simple interactive operation, in line with users' experience or easy to understand," and individual indicators with ambiguous descriptions were revised to form a set of evaluation index system consisting of 4 primary indicators, 12 secondary indicators, and 36 tertiary indicators.

4) Round II Consultation Questionnaire Distribution and Collection

According to the newly obtained index system, the round II consultation questionnaire was prepared, distributed, and collected again. Fifteen consultation questionnaires were distributed, and 15 were collected in this round, with a valid collection rate of 100%. The results of the consultation questionnaire were counted and calculated. The importance of all the indicators was more significant than 3.50, and the coefficient of variation C.V was less than 0.25, so all the indicators could be retained. The Kindle coordination coefficient was calculated, and the Kendall coordination coefficient was W=0.46 in this round. It is generally believed that $W \in [0.40, 0.50]$ indicates better coordination, and the consultation questionnaire can be stopped[7].

Through the above steps, an evaluation index system consisting of 4 primary indexes, including "content design," "function design," "interface design," and "interaction design," 12 secondary indexes, including "ontology display," "associated display," "basic function" and "expansion design," and 36 tertiary indexes, including "revolutionary cultural relics are selected to express the display theme well," "revolutionary cultural relics 3D model is of high quality, including small model error, realistic texture and natural light and shadow", "revolutionary cultural relics 3D model is completely displayed and highlighted", and "relevant information is complete and comprehensive, concise and easy to understand," has been established, as shown in Table 5.

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**Table 5:** Evaluation index system of 3d model display design of revolutionary cultural relics

| Tier 1 Indicator | Tier 2 Indicator | Tier 3 Indicator |
|---|---|---|
| C Content Design | C1 Main body Display | C11 Revolutionary relics selected to better express the theme of the display |
| | | C12 High-quality 3D models of revolutionary relics, including minor model errors, realistic texture, natural light, shadow, etc |
| | | C13 Revolutionary cultural relics 3D model display completely and focused |
| | C2 Affiliate Display | C21 The relevant information is complete and comprehensive, concise and easy to understand |
| | | C22 Relevant materials are displayed in a reasonable form |
| | | C23 Related materials can better interpret and assist the revolutionary cultural relics ontology display |
| | | C24 Relevant materials are attractive or interesting |
| F Functional Design | F1 Basic Functions | F11 Complete set of basic functions |
| | | F12 Clear hierarchy of basic function settings |
| | F2 Expanded Functions | F21 Expand the function can promote the revolutionary cultural relics display dissemination |
| | | F22 Expansion function module with an open interface |
| S Interface Design | S1 Layout Design | S11 The layout of the interface is well-partitioned, simple and neat |
| | | S12 Interface design is clear and focused |
| | | S13 Visually coherent and aesthetically pleasing interface design |
| | | S14 A uniform style of display interface at all levels |
| | S2 Color Design | S21 The primary color selection is reasonable, and the color imagery can meet or highlight the theme |
| | | S22 Color-coordinated design, in line with public aesthetics |
| | S3 Icon Design | S31 Icon design meets specifications |
| | | S32 Icons are semantically transparent and easy to understand |
| | | S33 Icon design is beautiful and uniform |
| | S4 Text Design | S41 Easy-to-read and legible fonts |
| | | S42 Font style fits the display theme |
| | | S43 The text layout is clear and easy to read, in line with the public's reading habits |
| | | S44 Text can be personalized to meet the reading needs of different people |
| I Interaction Design | I1 Waiting Design | I11 Short system response time and fast loading speed |
| | | I12 The design can alleviate the negative emotions generated by users during the waiting process |
| | I2 Tip Design | I21 Tips are comprehensive, detailed and accurate |
| | | I22 Clear and easy to understand cues |
| | | I23 Remarkable prompting methods, such as location, color, or accompanied by sound, vibration, etc. |
| | I3 | I31 Interaction is simple, consistent with user experience or easy to understand |

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| | | |
|---|---|---|
| | Operation Design | I32 Interaction parameters are set reasonably, including operation sensitivity, model rotation rate, etc |
| | | I33 Interactive operation feedback is reasonable, such as auditory, tactile, visual, etc |
| | | I34 Prevents user mishandling or easy recovery after mishandling |
| | | I35 Operation method with a certain degree of fun |
| | I4 | I41 Realistic and immersive audio-visual scenarios |
| | Audio-visual Design | I42 Audio-visual interaction is attractive |

## 3. Establishment of indicator weights

In order to determine the weight of each index, the consultation questionnaire was designed and issued for round III of the evaluation index weight of the revolutionary cultural relics 3D model display design, and the indexes were scored on a two-by-two comparison, and the scoring was based on the 1-9 scale method as shown in Table 6. Some of the data are shown in Table 7. 15 consultation questionnaires were distributed in this round, and 15 were collected with a valid return rate of 100%. At the same time, the consistency index CR and the weight of each index were calculated based on the results of the consultation questionnaire in round III by SPSSPRO software. Among them, CR < 0.10, through the consistency test, the revolutionary cultural relics 3D model display design evaluation index weights are shown in Table 8.

**Table 6:** 1-9 Scaling method

| Scale | Meaning |
|---|---|
| 1 | Both metrics have the same level of importance |
| 3 | The former indicator is slightly more important than the latter one |
| 5 | The former indicator is significantly more important compared to the latter indicator |
| 7 | The former indicator is extremely important compared to the latter indicator |
| 9 | The former indicator is strongly important compared to the latter indicator |
| 2, 4, 6, 8 | Median value for adjacency importance judgment |
| Countdown from 1-9 | Relative importance of two indicators after swapping order |

**Table 7:** Pairs comparison scoring table(partial data)

| | C11 | C12 | C13 | …… | I42 |
|---|---|---|---|---|---|
| C11 | 1.000 | 0.259 | 0.714 | …… | 0.938 |
| C12 | 3.867 | 1.000 | 0.333 | …… | 0.625 |
| C13 | 1.400 | 3.000 | 1.000 | …… | 0.682 |
| …… | …… | …… | …… | 1.000 | …… |
| I42 | 1.067 | 1.600 | 1.467 | …… | 1.000 |

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**Table 8:** Weights of evaluation index for 3D model display design of revolutionary cultural relics

| Indicator number | Indicator weights | Indicator number | Indicator weights | Indicator number | Indicator weights | Indicator number | Indicator weights |
|---|---|---|---|---|---|---|---|
| C | 0.277 | F | 0.216 | S | 0.254 | I | 0.253 |
| C1 | 0.654 | C2 | 0.346 | F1 | 0.671 | F2 | 0.329 |
| S1 | 0.309 | S2 | 0.249 | S3 | 0.223 | S4 | 0.219 |
| I1 | 0.247 | I2 | 0.225 | I3 | 0.309 | I4 | 0.219 |
| C11 | 0.175 | C12 | 0.482 | C13 | 0.343 | C21 | 0.319 |
| C22 | 0.220 | C23 | 0.217 | C24 | 0.244 | F11 | 0.607 |
| F12 | 0.393 | F21 | 0.566 | F22 | 0.434 | S11 | 0.277 |
| S12 | 0.241 | S13 | 0.252 | S14 | 0.230 | S21 | 0.491 |
| S22 | 0.509 | S31 | 0.386 | S32 | 0.310 | S33 | 0.304 |
| S41 | 0.337 | S42 | 0.257 | S43 | 0.219 | S44 | 0.187 |
| I11 | 0.521 | I12 | 0.479 | I21 | 0.347 | I22 | 0.344 |
| I23 | 0.309 | I31 | 0.215 | I32 | 0.201 | I33 | 0.184 |
| I34 | 0.188 | I35 | 0.212 | I41 | 0.502 | I42 | 0.498 |

## 4. Concluding remarks

Based on a large amount of relevant literature analysis, this paper integrates the Delphi method and hierarchical analysis method to construct a scientific, comprehensive, detailed, and transparent evaluation index system for the 3D model display design of revolutionary cultural relics, which can provide a clear direction for the in-depth and further optimization of the design scheme, effectively improve the quality of the 3D model display of revolutionary cultural relics, and promote the role of revolutionary cultural relics in "providing public cultural services, meeting the needs of people's spiritual and cultural life, and nurturing socialist core values."

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## References

[1] CHEN Bin,NIU Jin-wen,WAN Hong,et al. Research on three-dimensional modeling and display technology of a substation auxiliary equipment monitoring system[J]. Power System Protection and Control,2020,48(13):180-186.

[2] GAO Qing-yun,GAO Qing-xue,LIANG Fang. Reverse Design Practice of Tang Dynasty Mausoleum Statues Based on HTML5+VR Micro-Link[J]. Packaging Engineering,2021,42(22):330-336.

[3] HU Yun-gang,TAO Tao,WU Yu-hua,et al. Design and implementation of a three-dimensional display system for the Dazu Thousand-hand Bodhisattva rock carvings[J]. Sciences of Conservation and Archaeology,2015,27(z1):71-76.

[4] GONG Xue. Establishment of Diabetes Specialist Nurses Initial Accreditation and Evaluation Index System[D]. Jinan University,2014.

[5] SHEN Qi-yun,OU-yang He,OU-yang Yu-liang. Construction of the Evaluation Index System for the Achievement Degree of Production and Education Integration Goal[J]. Higher Education Exploration,2021(12):104-109.

ISSN: 2688-8653

[6] WANG Qing,ZHU Xiao-dan,CHANG RU,et al. Research on the construction of rehabilitation program for stable schizophrenia based on Delphi expert consultation method[J]. Journal of Modern Medicine & Health,2021,37(14):2357-2361.

[7] ZHANG Zhen,MA Li,LIU Gui-ping,et al. Core competency model for nurses in anesthesiology department based on Delphi method[J]. Occupation and Health,2019,35(21):2956-2960.