Research on User-Centered Digital Media Exhibition Design

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Keywords: New Media, Exhibition Design, Virtual Reality, Analytic Hierarchy Process (AHP), Design Methodology.

Abstract: In order to produce DMED for audience interaction experience that is consistent with the era of big data, use AHP to conduct a comprehensive evaluation of DMED. First, this paper uses literature research to summarize the concept and characteristics of new media exhibition design and AHP, then uses AHP to establish a DMED evaluation model, and then obtains the index weight value of each layer through expert scoring for analysis and comparison, and finally designs the project space through evaluation. The result has produced a exhibition space design based on the audience's visual interaction and integrating various new media technologies. Interactive AR display design with unity 3D software and computer programming. The new media technology based on the audience's visual experience is very important in the exhibition space design. The output of this paper can provide design ideas for other exhibition designs.

1 INTRODUCTION

With the change of new digital media technology (DMT) in the age of mega-data, the Digital media exhibition design (DMED) is no longer just the use of traditional exhibition methods, but also needs to have the technology update of resource optimization and allocation in it. According to statistics, in the global digital trend, many museums in China and the West have made digital optimization in exhibition, such as the British Museum, the Metropolitan Museum of the United States and the National Palace Museum of China have introduced DMT, which reflects that the digital industry is a new trend of exhibition space design and a key development direction. Therefore, The research on the exhibition space evolution of museums in the new media environment has become a new issue of concern to the academic research and relevant industries (Kang, 2020). Through comprehensive evaluation, we can understand its construction and measure the current development level, which can be used as a reference for the planning of DMED.

New media means interactive and digital composite media with network technology, communication technology and digital technology as the transmission carrier. With the development of digital information, new media has constantly evolved, changed people's information receiving methods and habits, and enhanced the media's communication power and influence. DMED is a space planning activity that serves the exhibition content, and the core purpose is to effectively spread some information or culture. The exhibition design plans the original space structure of the building, and plans and uses a certain space range through technical support and artistic techniques to conform to the atmosphere of the exhibition content. The design category of exhibition space tends to go beyond the view of simple space design, presenting a design of comprehensive methods.

Now traditional media begin to use information technology to change their own operation mode, and new digital media technology is also widely used in DMED. It has changed the traditional exhibition cabinet, booth and other forms, and adopted a variety of digital media, new science and technology to create a live exhibition atmosphere. Virtual augmented reality exhibition technology, 3D stereo and holographic interactive images, on-site interactive visual experience and other large-scale digital media exhibition design technologies for enterprises have made it widely used, which enables all visitors to obtain a truly comprehensive interactive experience (Hornecker, 2019). These technologies have historically changed the traditional art exhibition methods, and used these digital international exhibitions to develop new forms of expression for exhibitors. From the initial

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development of a single static form to the integration of various dynamic processes of human visual, auditory, olfactory and tactile interactions, people can participate more freely, actively and interactively (Vi, 2017).

Overview of AHP (Analytical Hierarchy Process) analytic hierarchy process: AHP is a practical multi scheme or multi criteria decision-making method proposed by American operations research scientist Professor Thomas L. Saaty in the early 1970s. This method uses a hierarchical method to express complex decision-making problems, and uses human subjective judgment and scientific methods to determine their advantages and disadvantages. At present, AHP has been widely used in various fields, creating good economic and social benefits for enterprises and society (Yu, 2021).

This study selects DMED as the research object, and uses AHP method to analyze the application of new technology in exhibition design. Establish the structural model and compare the weight of the selected design elements, so as to find out the successful way of the DMED in the application through the weight comparison, so as to further provide theoretical and data support for the DMED.

2 RESEARCH PROCESS

The research process of this article is as follows in this figure(fig1）:

(1) Pre-investigation to establish the theoretical basis, and theoretical analysis based on literature research.

(2) Listen to expert opinions and establish an AHP model for evaluation (Chang, 1996).

(3) Weight ordering based on evaluation results

(4) Project design from dissemination, suitability, interactivity and technicality.

3 RECENT RESEARCH

In China, many researchers have emerged in China to apply to space design and have made remarkable research achievements. Zhang made a brief interpretation of the theoretical method, practical application and research results of space design by exploring new media technology from different levels.

Juan summarized practical design methods of experiential exhibition space from architectural design, user application design and other aspects. In addition, in order to improve personal thinking about the design method of exhibition experience space. In addition, Chinese scholars Jin and Wen co authored a systematic introduction to the practical application, potential problems and future development of the popular digital exhibition design; In recent years, Qingqing and others elaborated the theoretical basis, research methods, design applications and development prospects of new media exhibition design from the basic new media technology and exhibition design theory, which has become a practical manual of Digital media exhibition design (DMED). These literatures objectively introduce the DMED theory, project practice, technology provision and the limitations of practical application, providing theoretical and technical references for this study.

Ronch pointed out that: "In the information age, digital media information has become the most popular way of cultural and artistic communication for the audience". Compared with traditional methods, multimedia information is more easily accepted by the public. Also, Sulema explored how to use digital media technology to integrate smell, touch, heat, etc. into media objects, so as to enrich traditional multimedia content and enhance immersion. Siorffe analyzed how to integrate digital media The technology is integrated into the space, forming the interaction between the audience and the physical space enhanced by technology. Susan McLeod discussed the adaptive design of the exhibition space under the application of digital media narrative technology in her research, further proposed the concept of new media technology applied to the exhibition design, and expanded the application of new media technology in multi type exhibition spaces.

Through the literature review, it is found that both focus on digital media technology innovation, and the research on how to reasonably layout technology and user experience study remains on the surface. From the existing research results, most of them ignore the synergy and differences of DMED. Therefore, it is of great theoretical and practical significance to study the evolution model of exhibition design in the new media environment by combining AHP, considering the differences of communication forms between new media and exhibition space.

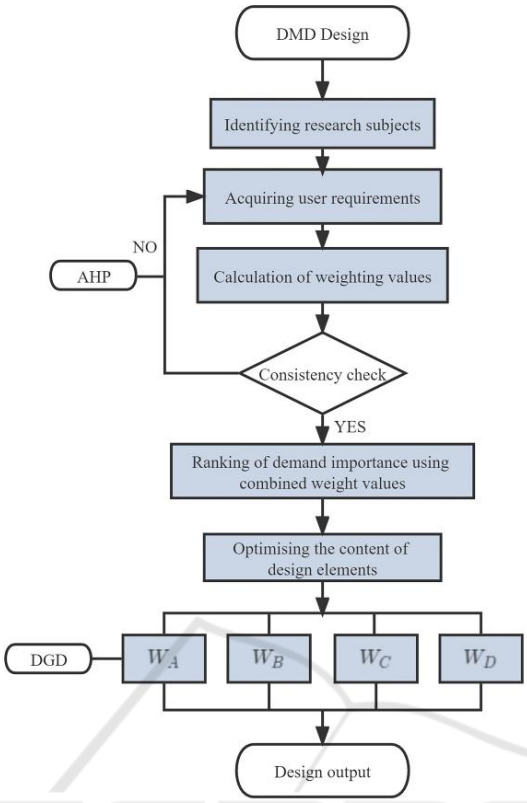

Figure 1: DMED Design Flow Chart

4 EVALUATION MODEL

4.1 Build A Hierarchical Analysis Model

DMED are not only reflected in the aspect of communication, but also the interactivity and technicality cannot be ignored. Stand at the visitor's point of view to establish an index system which follows the dissemination, suitability, interactivity and technical, and includes four dimensions and 20 indicators (Zancanaro, 2007), as shown in the this figure (fig 2).

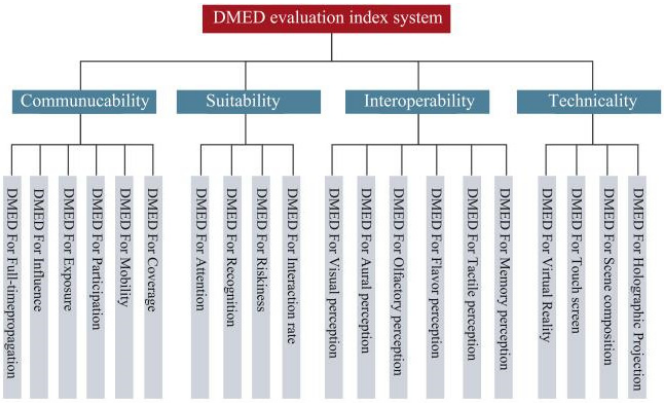

Figure 2: DMED evaluation chart

4.2 Build Judgment Matrix

AHP is used to calculate the preliminary subjective weight, and the pairwise judgment matrix constructed by seven experts on indicators according to the 1-9 scale theory is collected. The 1-9 scale and its significance are shown in this table(tbl1).

Table 1: Definition notes

Scale/a_{ij}	Definition notes
1	Two indicators have the same effect on one attribute
3	Compared with the two indicators, one indicator is slightly more important than the other
5	Compared with the two indicators, one indicator is obviously more important than the other
7	Compared with the two indicators, one indicator is much more important than the other
9	Compared with the two indexes, each element is extremely important
2、4、6、8	Scales when a compromise between the above two criteria is required
$1/b_{ij}$	Inverse comparison of two indexes

Establish the indicator system, and set the second level indicators as {ABCD}an shown in this table(tbl2).

Table 2: indicator system

CODE	A	B	C	D
A	1	2	5	5
B	1/2	1	2	3
C	1/5	1/2	1	1
D	1/5	1/3	1	1

This comparison uses the sum product method to calculate the eigenvector of the judgment matrix elements. First, calculate the sum of the columns, and then normalize the columns. Next, add the normalized matrix to the same row. Finally, divide the vector obtained after the addition by n to obtain the weight vector of each indicator. As shown in the table (tbl3).

Table 3: Weight value.

CODE	A	B	C	D	W_i
A	0.076	0.154	0.385	0.385	0.527
B	0.077	0.154	0.308	0.462	0.261
C	0.111	0.278	0.556	0.556	0.111
D	0.079	0.131	0.395	0.395	0.101

The specific steps are as follows:

Record the corresponding elements of the judgment matrix {ABCD} layer in the table as bij （i,j=1,2,...,4），

The elements in each column of the judgment matrix are normalized into:

$$\mathrm{bij} = \mathrm{bij} / \sum_{1}^{n} \mathrm{bij} \tag{1}$$

Add all columns in the same row of the normalized matrix, namely:

$$\mathrm{wi} = \sum_{1}^{n} \mathrm{bij} \tag{2}$$

Normalize wi, the formula is：

$$\mathrm{wi} = \mathrm{wi} / \sum_{1}^{n} \mathrm{wi} \tag{3}$$

Then: w=[w1 w2 w3 w4]=[0.527 0.2641 0.111 0.101] is the indicator weight.

In order to avoid the error between the subjective judgment matrix and the objective facts, the consistency test shall be conducted. The necessary and sufficient condition for the consistency of the n-order matrix is the maximum eigenvalue

$$\mathrm{AW} = \lambda \mathrm{W} \tag{4}$$

A is the judgment matrix; λ Is the characteristic value; W is the eigenvector. Minor inconsistencies in the judgment matrix are unavoidable and acceptable, and the consistency judgment is as follows.

the greatest characteristic root:

$$\Lambda \mathrm{MAX} = \frac{1}{\mathrm{N}} \sum_{\mathrm{I}=1}^{\mathrm{N}} \frac{(\mathrm{BW})\mathrm{I}}{\mathrm{WI}} = 4.016 \tag{5}$$

Judgment Matrix Consistency Index C.I., R. I is the random consistency index, C. R is a random consistency ratio

consistency index CI：

$$\mathrm{CI} = \frac{\lambda \mathrm{max} - \mathrm{n}}{\mathrm{n} - 1} = 0.005 \tag{6}$$

Random Consistency Indicators for Queries:

$$\mathrm{RI} = \frac{\lambda \mathrm{max} - \mathrm{n}}{\mathrm{n} - 1} = 0.882 \tag{7}$$

Consistent ratio CR：

$$CR = \frac{CI}{RI} = 0.006 \quad (8)$$

If CR < 0.1, consistency of the judgement matrix is acceptable. If CR < 0.1, the judgement matrix should be modified until consistency is acceptable. So CR=CI/RI=0.006<0.1, the above calculation shows that the judgment matrix achieves satisfactory consistency index and meets the consistency requirements, so the weight is valid, when the proportion of the four dimensions is 52.7%, 26.1%, 11.1%, 10.1%, respectively.

According to the above decision table construction, sample data processing and attribute weights calculation process, the importance and attribute weights of each factor in criteria layer and index layer are calculated respectively, and the results are shown in table and table.

Table 4: Evaluation results for communicability（A）.

CODE	A1	A2	A3	A4	A5	A6	Eigenvector	Weight (%)
A1	1	2	3	0.333	5	3	1.763	22.575
A2	0.5	1	2	0.333	3	1	1	12.807
A3	0.333	0.5	1	0.167	1	0.5	0.49	6.279
A4	3	3	6	1	6	4	3.302	42.286
A5	0.2	0.333	1	0.167	1	0.5	0.421	5.39
A6	0.333	1	2	0.25	2	1	0.833	10.664

“Communicability” result in this table(tbl4): Participation rate is relatively important in the criteria for assessing dissemination (0.423).

Table 5: Evaluation results for suitability（B）.

CODE	B1	B2	B3	B4	Eigenvector	Weight (%)
B1	1	0.5	0.333	0.25	0.452	8.611
B2	2	1	0.2	0.167	0.508	9.684
B3	3	5	1	0.5	1.655	31.54
B4	4	6	2	1	2.632	50.165

“Suitability” result in this table(tbl5): The interaction rate is relatively important in the suitability evaluation criteria (0.502).

Table 6: Evaluation results for Interoperability（C）.

CODE	C1	C2	C3	C4	C5	C6	Eigenvector	Weight (%)
C1	1	2	6	6	2	3	2.749	35.868
C2	0.5	1	4	4	1	2	1.587	20.708
C3	0.167	0.25	1	1	0.25	0.333	0.389	5.076
C4	0.167	0.25	1	1	0.2	0.5	0.401	5.233
C5	0.5	1	4	5	1	2	1.648	21.493
C6	0.333	0.5	3	2	0.5	1	0.891	11.622

“Interactivity” result in this table(tbl6): Visual perception is relatively important in the criteria for assessing interactivity (0.359).

Table 7: Evaluation results for technicality（D）.

CODE	D1	D2	D3	D4	Eigenvector	Weight (%)
D1	1	4	5	2	2.515	49.959
D2	0.25	1	2	0.5	0.707	14.047
D3	0.2	0.5	1	0.25	0.398	7.899
D4	0.5	2	4	1	1.414	28.094

“Technicality” result in this table(tbl7): Virtual reality technology is relatively important in the technical evaluation benchmark (0.500).

The results of the above analysis show that if the four dimensions "dissemination", "suitability", "interactivity" and "technicality" are used to promote the development of DMED, attention should be paid to improving the service level of high-tech design first, and then to strengthening the customer participation and experience of DMED in providing services. To improve audience interaction, especially the user experience, so that the audience can actively participate in it.

5 DESIGN PRACTICE

5.1 Project Background

The front door of Beijing is an important part of the historical and cultural area of Beijing. Due to the needs of civil air defense conditions in wartime, a network of civil air defense tunnels has been formed. Through the Qian-men Underground Museum project, relying on new media technology and various visual exhibition methods, a new cultural museum is created, which is inherited from top to bottom and integrates collection, research and exhibition.

1. Provide a exhibition platform for Beijing Qian-men culture

To preserve our original cultural memory, we used this museum to show the culture of the front door and describe the history of the area.

2. Integrate visual exhibition of digital media into traditional cultural space

Traditional culture is blended with new media technology in a limited space, with visual perception as the main exhibition method, and a large number of new media exhibition methods to make the audience experience a visual blending of traditional and modern art.

3. Rebuilding and utilizing the original underground space

In order to save land resources and economic expenditure, we have transformed the original space of Qian-men Underground City to avoid wasting space resources.

5.2 Design Output

The business area is one of the outlets of underground space in this figure (fig3(A)). Spatial division in the form of curves mainly deals in the creation of Qian-men culture. Relevant video is played in this area to directly introduce Qian-men culture and its derivatives to enhance the visual perception of the audience.

Space one in this figure (fig3(B)) introduces the old brand stores of the Qian-men which is moving in, moving out and still running. The overall design of the space uses virtual reality technology (AR) to simulate the form of plaques, transparent plaques to represent the disappeared brand, and black plaques to represent the changed in brand. The comparison between the two forms a visual impact, and LED video technology to introduce the brand in the back wall to enhance the audience experience.

Append a script to the model to display and drag AR of the model through Unity3d , as shown in this figure(fig 4).

```
using UnityEngine;
using System.Collections;
public class DragObject : MonoBehaviour {
    private Transform pickedObject = null ;
    private Vector3 lastPlanePoint;
    // Use this for initialization
    void Start () {
  }
  //
  void Update () {
//
        Plane targetPlane = new Plane(transform.up, transform.position);
        foreach (Touch touch in Input.touches) {
            //
            Ray ray = Camera.main.ScreenPointToRay(touch.position);
            //
            float dist = 0.0f;
           targetPlane.Raycast(ray, out dist);
            //
            Vector3 planePoint = ray.GetPoint(dist);
            //Debug.Log("Point=" + planePoint);
            //
            if (touch.phase == TouchPhase.Began) {
                RaycastHit hit = new RaycastHit();
//
                if (Physics.Raycast(ray, out hit, 1000)) {
                    pickedObject = hit.transform;
                    lastPlanePoint = planePoint;
                } else {
                    pickedObject = null ;
                }
            //
            } else if (touch.phase == TouchPhase.Moved) {
                if (pickedObject != null ) {
                    pickedObject.position += planePoint - lastPlanePoint;
                    lastPlanePoint = planePoint;
                }
            //
            } else if (touch.phase == TouchPhase.Ended) {
                pickedObject = null ;
            }
        }
    }
}
```

Figure 4: Cut code

Space two in this figure (fig3(C)) shows the emergence of new things in modern Beijing that first appeared in Qian-men area, which is reflected in the leading role of Qian-men as a commercial center in several fields in the process of the modernization of the ancient capital. The space takes tram as the starting point, and displays the real form simulation of the old Beijing tram in the exhibition hall. The window is an interactive screen for the audience, showing the "news" of the old Beijing, as if those histories were already in sight, creating a variety of different visual effects for the audience. In the headquarters area, a control screen has been added, which enables the audience to interact with each other, to arouse the interest of the audience and to gain a deep understanding of this culture.

Due to the limitations of underground space and narrow aisles, a single form is used to prevent people from jamming.

The left wall displays the relevant documents of the time when the air defense shelter was built. The photo is used as the base of the exhibition wall, and the traditional visual way is used to spread the exhibition so that the audience has a basic understanding of civil defense in wartime. The right side uses projection technology to introduce the real scene at that time to the audience, so that they can recognize the difficulty of war. The place as shown in this figure (fig3(D)).

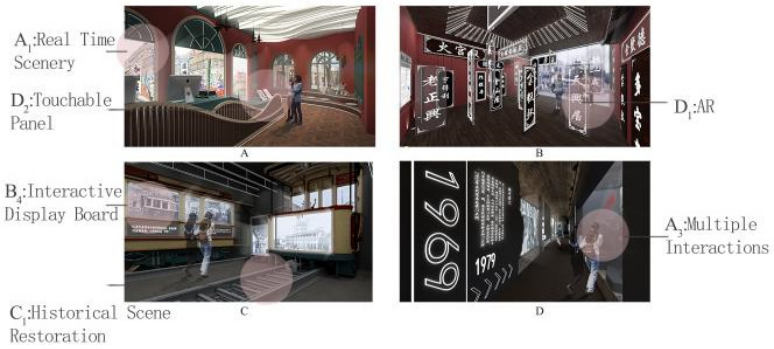

Figure 3: Design element description

6 CONCLUSION AND FUTURE RESEARCH

The application of new media has significantly improved the dissemination rate and audience interaction rate of exhibition space, and improved the wartime environment. More and more exhibition designs have introduced new media technology for spatial exhibition. Based on the new media and exhibition design theory, this paper constructs a DMED evaluation model for data analysis. The data results verify the validity of the model, and provide a new theoretical perspective and practical direction for how to use more effective methods and innovative technologies for spatial exhibition in DMED. In the final project practice, it combines virtual reality technology, holographic projection technology and historical scene restore methods to be used in various spaces to enhance the interactive experience of the audience. A DMED project in Beijing was produced and received good reviews. Future research will further explore historical scene restoration in the VR, increasing immersion from a technical perspective.

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