

Research on Digital Exhibitions of Shandong Art Museum Based on Children's Experience Mechanism

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Abstract: In the era of digital intelligence, Shandong Art Museum has adapted to the growing trend of child audiences and provided a new path for children's education through the construction of digital art Spaces. Based on the theory of children's cognitive psychological processes, this paper adopts sensory preference tests, interview methods and questionnaire surveys to analyze the digitization path of Shandong Art Museum from three experience dimensions: the stage of receiving information (sensory level), the stage of understanding information (thinking level), and the stage of storing information (memory level). This article proposes child-friendly digital exhibition strategies such as constructing multi-sensory immersive experiences, human-computer interactive social learning, and a closed loop of online and offline education, to assist art museums in realizing the value of digital children's education and cultural dissemination. Future research can further expand the scope of study and verify it by combining more cases of art galleries in different regions and types, so as to improve the theoretical framework and promote practical application.

Keywords: Shandong Art Museum, children's cognitive psychology, digital exhibition, immersive experience, Jinan City

1. Introduction

With the rise of new museology and the advent of the digital age, the concept of "people-centered" is driving the digital transformation of museums in China. The application of technologies such as artificial intelligence and VR not only innovates display methods but also meets the multi-level needs of audiences through functional adaptation and diversified services. Shandong Province has actively responded to this trend by incorporating museum education into the curriculum of primary and secondary schools, launching the "Museum into Campus" program and other policies, and investing special funds to promote digital construction, achieving full coverage of digitization in three-level museums and the development of virtual exhibition halls. In 2023, Jinan and Qingdao were selected as national "cloud exhibition" pilot cities, marking that under the guidance of the "people-oriented" spirit, the deep integration of digital technology and physical exhibition halls has achieved remarkable results, creating a richer cultural experience space for the audience[1][2][3][4][5][6][7].

However, there are still many deficiencies in the current children's experience design of museums: Poor narrative coherence leads to fragmented experiences; The content was not designed for the cognitive characteristics of different age groups; Weak parent-child interaction The form of interaction is monotonous and lacks interest; The service system lags behind; Virtual exhibitions are highly homogeneous; Insufficient research on digital education[8][9][10]. In order to improve the above problems, this paper studies the digital exhibitions of Shandong Art Museum based on the theory of children's cognitive psychological processes. It proposes possible child-friendly exhibition paths for art museums for children aged 6 to 12, helping art museums exert their educational functions for children.

2. Overview

Museums, generally non-profit permanent institutions serving the society, undertake the functions of cultural heritage protection, research and education [20]. In recent years, under the impetus of the national cultural digitization strategy, the digitization of museums has developed rapidly. Relevant policy documents such as "Opinions on Promoting the Implementation of the National Cultural Digitization Strategy" have provided policy support for it. At present, the digitization of museums mainly includes four directions: cultural relic protection, operation and management, exhibition and display, and digital cultural and creative products. Among them, the digitization of exhibition and display innovates exhibition and display methods through three forms: twin type, derivative type and independent type[11].

Experience design is a user-centered design concept, emphasizing starting from people's subjective feelings and shifting the design purpose from technology-oriented to life experience[12]. Modern museums are increasingly attaching importance to the participation and experience of the audience, achieving a fundamental difference from the traditional museum model through two-way information transmission [13]. From this, we can know that in art museum education, a "child-friendly"

learning environment should be established [1]. However, current practice shows that art museums and related research pay insufficient attention to children's needs in terms of interaction methods and service systems. Therefore, further attention and design by art galleries to children's experiences are the development directions that can be considered next.

Based on Piaget's cognitive development theory, children aged 6 to 12 who are in the specific operation stage and the intermediate thinking stage and have certain logical abilities are the most effective group for digital museum education[14], and therefore are also the research objects of this paper. The cognitive process of children is divided into three stages: receiving, understanding and storing information, corresponding to the three experience levels of senses, thinking and memory [13]. At the sensory level, children prefer visual elements that are concrete and rich in color, auditory experiences that are contextualized, and tactile devices that are highly interactive [1]. At the level of thinking, children's cognition is easily disturbed and requires a smooth cognitive process. At the same time, they have the characteristics of exploration and dependence. Interactive collaboration can enhance the effect of understanding[15]. At the memory level, cognitive memory is superior to mechanical memory, and continuous experience can enhance information storage[16]. The combination of art and digital technology is the channel for the future dissemination of art. Immersive panoramic performances offer multi-sensory experiences, and this approach enables art to attract young audiences of the future[17]. Therefore, this article will innovate the digital exhibition education approach for children aged 6 to 12 in art museums based on children's cognitive psychology, to help art museums in China better utilize their rich cultural and educational resources and realize the contemporary value of children's education.

3. Three research method

With the popularization of digital technology in museum exhibitions, the academic community has conducted extensive discussions on the audience learning models and effectiveness of digital displays. Due to the diversity of learning types, the complexity of cognitive processes, and the multiplicity of learning outcomes, relevant studies have adopted a diverse assessment method system: It includes both qualitative research methods such as in-depth interviews and preference tests, as well as quantitative research methods such as questionnaires[18], to study the cognitive and psychological characteristics of children aged 6 to 12, providing ideas and references for new ways of digital exhibition education.

3.1 Sensory preference test

To study the visual, auditory and tactile biases of children during the information reception stage, the author conducted corresponding sensory preference tests on children aged 6 to 12. During the visual test session, the researchers prepared pictures of exhibits and scene designs with different color saturation levels, and tracked and observed them through eye trackers. In the auditory test, the ABX double-blind test method was adopted, allowing children to listen to different types of background music. In the tactile test, the method of setting up a control group was adopted. Children were divided into the interactive participation group and the simple viewing group for the test.

3.2 Interview method

To study the cognitive preferences of children in the information understanding stage, the author conducted an in-depth investigation among 60 children aged 6 to 12 using the semi-structured interview method. The author first set up an observation area in the digital exhibition hall of Shandong Art Museum, randomly selected 60 child visitors for tracking observation, and recorded their interactive behavior characteristics. Subsequently, the "Voice thinking method" was adopted, inviting 30 groups of children and their parents to describe the thinking process in real time during the visit. The interview questions focus on three dimensions: 1) "Can you understand what this exhibit is about?" 2) "Which part do you think is the most interesting? Why?" 3) "Who is the most interesting to visit the exhibition with?" .

3.3 Questionnaire survey method

To study the memory patterns of children in the information storage stage, the author adopted the method of questionnaire survey to evaluate the memory effect of children aged 6 to 12. Structured questionnaires were distributed to 60 children who had just visited the immersive digital art exhibition "Qi World-Light-Meet-Healed" at Shandong Art Museum. The questionnaire design includes three key dimensions: 1) Immediate memory test (evaluating the memory accuracy rate of key information of the exhibits through multiple-choice questions); 2) Delayed memory test (call back with the same questions two weeks later); 3) Continuous experience evaluation (investigating children's willingness to participate in subsequent interactive activities).

4. Research process

4.1 Information reception stage (sensory level) path

According to the research in the previous section, it can be known that the application of digital technology in art galleries to construct contextualized learning environments has significant educational value. By adopting technical means such as naked-eye 3D display, digital painting restoration, immersive light and shadow, sound and projection interaction, universal display screens, and CT scanner imaging[19], a multi-sensory participation learning experience can be created for children aged 6 to 12. This multi-dimensional way of presenting information not only enhances the interest and interactivity of the exhibition, but also makes abstract concepts concrete, effectively improving children's efficiency in receiving and understanding the information of the exhibits, thereby promoting the development of their cognitive abilities.

4.1.1 Visual experience

The "Spiritual Realm-Crossing the Realm of Spiritual Resonance" immersive digital art exhibition at Shandong Art Museum makes full use of light and shadow art in multiple sections, creating an atmosphere and immersive environment with bright and rich colors. Children can better gain a sense of beauty from these sections, such as "Time Machine", "Spiritual Guidance Theater", and "Lost in Thought and Immersed in Painting". All of them use light and shadow to create a unique visual space, embedding the paintings and themes in a dazzling array of colors, and creating an area with a strong sense of ceremony, spirituality and visual impact.

4.1.2 Auditory experience

In the Shandong Art Museum "Qi World-Light-Meet-Healed" exhibition, the 5D dynamic U-screen cinema "Light Realm - Underwater World" combines situational sound with stereoscopic dynamic visual effects, allowing children to experience the mysterious and magnificent underwater world in an immersive way.

4.1.3 Tactile experience

Children can create their own multi-style artworks on the spot in the "Painting Realm - Intelligent Beauty Gallery" section of the "Qi World-Light-Meet-Healed" exhibition at Shandong Art Museum; In the "Ancient Shu Bronze" section of the immersive digital art exhibition "Spiritual Realm-Crossing the Realm of Spiritual Resonance", children can draw simple geometric shapes. The system will search for and display representative bronze wares related to the drawn shapes, deepening children's memory and understanding of bronze wares.

4.2 Understanding the information stage (thinking level) path

The research results of the previous section indicate that enhancing children's interaction experience with exhibits and peers through digital exhibition technology can effectively promote the development of their thinking and cognitive abilities. Specifically, digital exhibitions, by creating interactive scenarios and designing collaborative sections, not only enhance the in-depth interaction between children and exhibits but also promote communication and cooperation among visitors, which is conducive to improving the quality of children's learning experience at the thinking level. This interactive learning mode enables children to actively construct knowledge during the participation process, cultivate critical thinking ability, and ultimately achieve the optimization and improvement of the thinking level.

4.2.1 The interaction between people and objects

In the "Infinite Sea - Immersive AI Digital Art Exhibition" section of the Shandong Art Museum, under the theme of "3D: The Sea of Reality", children can input their MBTI personality into the device to reorganize the Marine creatures in the three-dimensional world, generate their own unique Marine creatures, and display them. In the "5D: Sea of Concepts" exhibition area, through portrait collection technology, the exhibition can input children's images into the installation screen and integrate them into the digital ocean in the background, completing a fusion and co-creation of individual consciousness and collective trends, achieving interaction and co-creation between children and the exhibition, and deepening their impression and understanding of the exhibition content.

4.2.2 Person-to-person interaction

In the "Infinite Sea - Immersive AI Digital Art Exhibition" of Shandong Art Museum, in the "2D: Sea of Civilization" section, children can paint together with their parents and peers on tablets, adding their own "brush and ink" to traditional Marine masterpieces. Through shared experiences, they can understand and recreate these masterpieces.

4.3 Information storage stage (memory level) path

The research results of the previous section show that transforming children's creative achievements in digital exhibitions into offline mobile exhibitions or public welfare projects, etc., can not only highlight the social value of the works, but also effectively enhance children's achievement motivation. Meanwhile, by establishing an online display platform and

combining it with long-term interactive mechanisms such as regular knowledge card delivery and souvenir rewards, children's learning and memory can be continuously strengthened. This provides important inspiration for the optimization and upgrading of the digital exhibitions of Shandong Art Museum: In the future, it is possible to focus on building a complete educational closed loop of "creation - display - feedback", adopt an extended educational strategy, and further deepen children's artistic experience and cognitive development through a continuous interactive model combining online and offline.

5. Research results

Based on the sensory preference test, interview method and questionnaire survey method mentioned earlier, the author has obtained the following research results:

In the sensory preference test, children generally spent more time looking at exhibits with bright colors than those with solid colors, and showed a stronger willingness to explore scenes with multiple color combinations. Auditory experiments show that it prefers sound effects with a light rhythm and strong narrative, and such sounds can prolong its stay time. Tactile experiments show that children participating in interactive installations have a higher accuracy rate in remembering the exhibits than those in the simple viewing group, and interactive behaviors can stimulate more questions. Overall, multi-sensory collaborative stimulation such as contextualized visual design, immersive sound elements, and tactile interaction can significantly enhance children's cognitive participation, strengthen their sense of immersion, and deepen their memory.

In the interview study, the author found that children generally believed that dynamic exhibits were easier to understand, confirming that digital interaction could enhance cognitive fluency. In terms of preferences for interactive forms, autonomous operation of devices is the foundation, while parent-child collaboration and peer competitions can further enhance efficiency - the parent-child group has a more accurate understanding of the connotations of the exhibits, and the peer group completes tasks more quickly, confirming the effectiveness of the constructivist learning situation. Just as a 9-year-old child put it, "When I was doing the number puzzle with my dad, the stories he told made the patterns interesting," vividly demonstrating the promoting effect of multi-subject interaction on knowledge transfer.

The results of the questionnaire survey showed that the immediate memory accuracy rate of the children group participating in the creative activities (n=23) reached 78% (significantly higher than 54% of the group simply visiting the exhibition (n=37)), and the memory retention rate after two weeks was also significantly higher than that of the group simply visiting the exhibition. 85% of children hope that their works will be displayed, and 85% expect to receive knowledge cards online, demonstrating the reinforcing effect of achievement motivation on memory. Data confirms that extending exhibitions to offline and online interaction can effectively enhance children's memory effects, providing empirical evidence for art museums to optimize digital education and better provide children's educational services.

Based on the above research on children's cognitive psychology and the analysis of the excellent examples of digital exhibitions at the Shandong Art Museum, in view of the insufficiency of experiential education for children aged 6 to 12 in current art museums, the author proposes the following new paths for the adaptation of digital exhibitions to children that art museums may implement.

5.1 The adaptation of the intelligent tour guide system for children

As children tend to focus on bright colors and scenes with multiple color combinations, and prefer sound effects with a lively rhythm and strong narrative, art galleries can build a digital guidance system suitable for children to optimize their experience. The first is to design a child-friendly indication system, using multi-color and bright color ICONS and children's voice prompts; Second, it is equipped with intelligent tour guide devices to simplify the transmission of knowledge through personified images and game tasks.

5.2 Virtual avatars and situational interaction design

The research results show that digital interaction can enhance the fluency of children's cognition. Therefore, art galleries can set up cartoon characters as virtual tour guides, interact with children through holographic projections, and explain the exhibits in interesting language. At the same time, develop interactive games, such as allowing children to assemble fragments of cultural relics through touch screens and unlock animations, to enhance their sense of participation and knowledge memory in the "character+game" mode.

5.3 Upgrade of immersive experience with multi-sensory collaboration

The multi-sensory integration design, including visual scenarios, auditory immersion and tactile interaction, can effectively enhance children's concentration when visiting exhibitions and strengthen their sense of situation immersion and knowledge memory. Art galleries can optimize interactive installations, adopt force feedback technology in the tactile experience.

rience area to simulate the touch of exhibits, and pair it with situational sound effects. Customize soundscapes in line with the exhibition theme and enhance children's perceptual experience and memory effect through multi-sensory interaction.

5.4 Construction of socialized learning mechanisms

In terms of interactive forms, children's autonomous operation of devices is the foundation, while parent-child collaboration and peer competitions can further enhance efficiency. Art galleries can effectively enhance children's participation in exhibitions by establishing collaborative competition mechanisms such as AR parent-child collaboration tasks and group knowledge quizzes, which not only stimulate their learning motivation but also meet their social needs. This model that combines teamwork with healthy competition can not only meet children's social interaction needs, but also effectively stimulate their sense of achievement in learning and motivation for continuous participation.

5.5 Establishment of a closed loop for continuous education

Extending the exhibition to the offline and online interaction after the visit can effectively enhance children's memory. Therefore, art galleries can build an educational extension and closed loop through the integration of online and offline channels. Offline, generate electronic picture albums of children's digital works, scan the code to save them and push relevant knowledge. Set up a virtual exhibition hall online to provide resources such as exhibition reviews and interactive games, forming a circular model of "physical creation - cloud storage - knowledge push", to enhance children's memory and understanding of cultural content and achieve continuous education.

6. Conclusion

Against the backdrop of the digital wave and the growing group of children in art galleries, how digital technology can optimize children's art gallery experience and make up for the insufficiency of educational design is an important issue with both academic and practical value. This study takes the digital art space of Shandong Art Museum as a typical case. Through the combination of empirical research and theoretical analysis, it explores the innovative path of digital exhibitions based on children's cognitive characteristics, making up for the insufficiency of art museums in paying attention to children's needs in terms of interaction methods and service systems. The research finds that the experience of children's art galleries has phased characteristics and needs to be designed from three aspects: senses, thinking and memory. At the sensory level, technologies such as naked-eye 3D are adopted to enhance participation; At the thinking level, collaborative abilities are cultivated through interactive devices and social learning. At the memory level, online interaction is utilized to extend the retention of knowledge. This research not only reveals the intrinsic connection mechanism between digital exhibitions and children's cognitive development, but also constructs the digital logical framework of Shandong Art Museum based on the perspective of children's cognitive psychology, innovates the digitalization path of art museum exhibitions suitable for children, and strives to realize the contemporary value of children's education and cultural dissemination in art museums.

However, this article still has some limitations. In the future, related research can be adjusted and expanded by taking multiple types of art museums in various regions as samples, promoting the development of child-friendly digital exhibitions in art museums in China through theoretical research, and realizing the contemporary value of children's education and cultural dissemination in art museums.

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