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ORIGINAL

The Effectiveness of The Conceptual Model of Virtual Museums in Children's Art Learning: Expert Review

La Eficacia del Modelo Conceptual de Museos Virtuales en el Aprendizaje del Arte Infantil: Análisis de Expertos

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ABSTRACT

Introduction: a new age of digital revolution in children's art education calls for creative teaching strategies. With its immersive and interactive qualities, virtual museum technology presents special chances to foster children's creative growth, creativity, and involvement.
Objective: with a focus on organized, kid-centered experiences that encourage in-depth learning and engagement, this research offers a conceptual model for virtual museums designed specifically for kids' art education.
Method: three rounds of expert review were used to verify the model. The model's theoretical worth, applicability, and flexibility were emphasized in expert input, which also offered helpful recommendations for its development.
Results: the results show that this conceptual model provides useful advice for creating virtual museum settings that successfully enhance kids' art education. Prototype creation and empirical studies will be part of future research to assess the model's effects on learning outcomes, engagement, and creative development.
Conclusions: the proposed conceptual model offers a structured framework for leveraging virtual museums to enrich children's art education, fostering creativity, engagement, and deeper learning. Its validation through expert review underscores its theoretical and practical relevance, with future research set to explore its real-world educational impact.

Keywords: Virtual Museum; Children's Art Education; Engagement; Conceptual Model; Expert Review.

RESUMEN

Introducción: la nueva era de la revolución digital en la educación artística infantil exige estrategias de enseñanza creativas. Con sus cualidades inmersivas e interactivas, la tecnología de los museos virtuales ofrece oportunidades especiales para fomentar el crecimiento creativo, la creatividad y la participación de los niños.
Objetivo: centrada en experiencias organizadas y centradas en los niños que fomentan el aprendizaje profundo y la participación, esta investigación ofrece un modelo conceptual para museos virtuales diseñado específicamente para la educación artística infantil.
Método: se realizaron tres rondas de revisión por expertos para verificar el modelo. Su valor teórico, aplicabilidad y flexibilidad se destacaron en las aportaciones de los expertos, que también ofrecieron recomendaciones útiles para su desarrollo.
Resultados: los resultados muestran que este modelo conceptual ofrece consejos útiles para crear entornos

de museos virtuales que mejoren con éxito la educación artística infantil. La creación de prototipos y los estudios empíricos formarán parte de futuras investigaciones para evaluar los efectos del modelo en los resultados de aprendizaje, la participación y el desarrollo creativo.
Conclusiones: el modelo conceptual propuesto ofrece un marco estructurado para aprovechar los museos virtuales y enriquecer la educación artística infantil, fomentando la creatividad, la participación y un aprendizaje más profundo. Su validación mediante revisión por expertos subraya su relevancia teórica y práctica, y se prevé que futuras investigaciones exploren su impacto educativo en el mundo real.

Palabras clave: Museo Virtual; Educación Artística Infantil; Participación; Modelo Conceptual; Revisión por Expertos.

INTRODUCTION

Children's art education now has access to previously unheard-of possibilities thanks to the quick development of virtual museum technologies and the acceleration of the digital revolution in education. Virtual museums offer students the chance to explore a variety of artistic and cultural content in an immersive, personalized, and interactive setting, surpassing the limitations of traditional museum visits, which are restricted by physical venues and resource accessibility. In art education, where learning results depend heavily on high levels of engagement, inventiveness, and emotional resonance, this progression is particularly noteworthy. Numerous studies have shown that via first-person exploration, creative expression, and social cooperation, immersive virtual worlds may successfully foster children's curiosity, critical thinking, and persistent engagement. Virtual museums provide a fresh platform for art instruction, but there is still a fundamental problem that has to be addressed: how to assess children's learning involvement in virtual environments scientifically and effectively? Teachers and designers have difficulties in optimizing the experience since existing models often lack systematic and multidimensional viewpoints, making it difficult to effectively capture children's cognitive and behavioral performance in digital learning environments.

This study suggests and supports a conceptual model of virtual museums created especially for kids' art education in order to fill this research gap. The model underwent many rounds of expert examination utilizing a well-known expert review approach to guarantee theoretical rigor and practical usability. Using organized questionnaires and online interviews, we asked seven professionals with more than five years of VR, design, or educational technology expertise to do methodical evaluations of the model's structure, technological concepts, user groups, and prototype development.

This study's primary contribution is the creation of a novel conceptual model for virtual museums that aims to improve kids' art education. To encourage children's creative curiosity, inventiveness, and deep involvement, the model methodically incorporates immersive multimedia components and multifaceted interactive experiences. This approach encourages children's art education and virtual museums to integrate theory and practice. For educators, curators, and developers looking to use virtual reality technology to enhance children's art learning in a variety of educational settings, this study offers structured design ideas and helpful implementation guidance through methodical construction and several rounds of expert review.

Literature Review

Virtual Reality

The use of virtual reality (VR) technology in art instruction has grown in popularity in recent years.[1] In research carried out at the China Academy of Art's Department of Industrial Design,[2] created a system for virtual visits, exhibitions, and personalized creative virtual spaces. The study found that VR enhanced students' creative engagement and strengthened teacher-student interaction, offering an immersive and spatially unrestricted learning environment. International research similarly supports the advantages of VR in education. A review of VR applications in art education and pointed out that VR can promote creativity, accessibility, engagement, and experiential learning across educational levels from primary schools to higher education.[3]

However, [1] noted that most VR research has concentrated on higher education, and there is relatively limited empirical work focusing on early childhood and primary school art education. Moreover, in China, most practical projects remain at the stage of technical demonstrations or short-term interventions, lacking longitudinal analysis of children's learning outcomes and aesthetic development.[4]

Virtual Museums

As innovative digital platforms, virtual museums have rapidly overcome the constraints of physical space and time, offering unprecedented access to artistic and cultural resources, especially for children.[5] Recent studies show that virtual museum environments integrated with 3D visualization, VR/AR, and gamified interactive technologies can significantly enhance users' engagement, curiosity, and learning satisfaction.[6,7]

These environments not only enable personalized, multimodal, and interactive experiences but also expand the reach of art education and support individualized learning paths.[8]

However, despite the many advantages of virtual museums in education, scholars have pointed out common limitations in current systems, such as shallow interaction depth, lack of adaptive feedback, and insufficient user-centered design factors that constrain their educational effectiveness. Therefore, there is an urgent need to construct theoretical models and practical frameworks that systematically integrate technology, pedagogy, and developmental needs, with special attention to children as a core user group.[9]

Children's Art Learning

Children's art learning in digital and virtual environments increasingly emphasizes creativity, emotional engagement, and collaborative exploration. Empirical studies have found that immersive museum environments not only promote children's cognitive development but also enhance emotional resonance, social awareness, and artistic expression capabilities.[10,11] Compared with traditional classroom-based art education, virtual art learning environments offer greater flexibility and provide diverse, visually rich experiences that involve interaction with digital artworks, engagement in creative problem-solving, and collaboration with peers.[12]

However, to truly achieve these educational goals, it is essential to ensure that the design of digital environments aligns with children's cognitive characteristics and developmental needs. Scholars therefore recommend incorporating tiered guidance and adaptive feedback mechanisms in virtual art learning to optimize learning processes and improve learning outcomes.[13]

METHOD

Description of Proposed Model

The conceptual model of the VR museum proposed in this study consists of two core structural levels: the technical layer and the design principles layer. The technical layer establishes the system's foundational architecture, covering key elements such as museum structure, technology, and users. It includes the process design of the opening area, content area, and closing area to ensure the completeness of the visiting experience; it clearly defines the required hardware and software resources (e.g., VR devices, offline platforms); and it positions the roles of developers and child users. In addition, the development process is incorporated into this layer to ensure the project progresses efficiently along the path of needs analysis, prototype development, user evaluation, and product iteration.[14]

Correspondingly, the design principles layer provides an educational and interactive design blueprint for the VR museum. This layer specifies best practices for the application of multimedia elements such as text, 3D models, graphics, videos, games, and audio, emphasizing clarity, quality, and educational value. It also defines core standards for multimedia design, virtual environment creation, interface and navigation, and interaction design focusing on child-friendly interfaces, immersive experiences, and meaningful learning outcomes. This ensures that every detail of the virtual museum contributes to active learning and deep engagement.[15]

The two core levels collaboratively construct a complete VR museum development framework aimed at children's art education. The technical layer ensures system functionality and implementation feasibility, while the design principles layer enhances the learning experience through evidence-based, user-friendly, and highly engaging design strategies. This dual-level integrated model not only promotes the organic integration of technology and education but also ensures the innovation and effectiveness of the VR museum in stimulating children's art learning and creativity.

Table 1. Technical Components of the VR Museum Conceptual Model

Component	Element	Included in Model
Structure	Opening Area	Essential
	Content Area	Essential
	Closing Area	Essential
Technical	VR Devices	Essential
	Software/Hardware	Essential
	Platform	Essential
User	Developer	Essential
	Children	Essential
Development Process	Iterative Process	Recommended

Ultimately, the technical layer is defined by structural components (opening area, content area, closing area), technical components (VR devices, software/hardware, platform), and user components (developers and children); the design principles layer includes multimedia elements (text, 3D models, graphics, videos, games, audio) and specific principles for multimedia design, virtual environment design, interface and navigation design, and interaction design.[16] The inclusion criteria for each element are based on literature and empirical research and are classified as "essential elements" and "recommended elements."

Table 2. Design Principles Layer Components of the VR Museum Conceptual Model

Component	Element	Included in Model
Multimedia	Text	Essential
	3D Models	Essential
	Graphics	Essential
	Video	Essential
	Game	Recommended
	Audio	Essential
Design Components	Multimedia Design	Essential
	Virtual Environment Design	Essential
	Interface & Navigation Design	Essential
	Interaction Design	Recommended

Phase I – Experts Identification and Selection

Expert review, widely recognized as an effective method in the field of educational technology and model validation, was adopted in this study. The first part provided detailed instructions and guidelines to ensure that reviewers understood the purpose and procedures of the evaluation. The second part collected demographic data of the expert reviewers, including name, age, gender, education level, professional field, and years of experience. The third part was a structured evaluation questionnaire designed to assess the scientific validity, practicality, and logical integrity of the proposed virtual museum conceptual model from five key aspects.

The main goal of this phase was to select experts with theoretical and practical experience in virtual reality, educational technology, children's art education, and related fields. Based on authoritative research recommendations, the following selection criteria were established:

Education Requirement: Possession of a doctoral degree in relevant fields such as educational technology, virtual reality, art education, or human-computer interaction; Experience Requirement: over five years of research or industry practice in VR, educational technology, child development, or related domains. Based on these criteria, a preliminary list of expert candidates was compiled.[17] Invitations were sent via email to representative scholars and practitioners in the fields of virtual museum development and children's art education in China. Ultimately, [please insert actual number, e.g., "six"] experts agreed to participate in the review, a number that meets standard practice for model validation in this field.

Table 3. Demographic Profiles of Experts

Expert	Gender	Education	Years of Experience	Specialization
A	Female	PhD	19	Virtual Reality
B	Male	PhD	25	Art Education
C	Female	PhD	19	Human-Computer Interaction
D	Male	PhD	12	Design Studies
E	Female	PhD	20	VR Technology
F	Male	PhD	5	VR Technology
G	Male	PhD	19	VR Technology

Phase II – Instrument and Procedures

The goal of the second phase was to systematically assess the logical structure, educational appropriateness, and practical feasibility of the VR museum conceptual model through structured expert review. To validate the model's effectiveness, an expert review questionnaire was designed as the primary feedback instrument.[10] The questionnaire was divided into three main parts:

Evaluation of the clarity and understanding of the terms and structure used in the VR museum conceptual model[2] assessment of the relevance, sufficiency, and completeness of the core components and design principles in the context of children's art learning;[3] experts' opinions, suggestions, and in-depth insights on the model's strengths and areas for improvement.[18] Additionally, the questionnaire collected basic information such as research field and professional experience and encouraged experts to provide supplementary suggestions for model optimization or educational value enhancement. The expert review process was conducted in two rounds. The first round focused on initial evaluations of the model's overall framework, core elements, and theoretical logic. All feedback and suggestions were carefully documented.[4] The model was then revised based on expert input and sent back to the expert panel for a second round of review, emphasizing the validity of the revisions and the model's practical feasibility in the context of children's virtual art learning. Considering the diverse locations and fields of the participating experts, the review process was primarily conducted via email and online meetings. Experts were given two weeks to complete their evaluations and submit the questionnaires. The research team systematically analyzed the collected feedback to assess the model's scientific soundness, practicality, and application potential in children's art education.[9]

RESULTS

There were three rounds of the VR Museum Conceptual Model evaluation process. The expert panel's first round included a preliminary assessment of the model's main elements and general structure, with an emphasis on its viability.[19] At this point, every expert comment and recommendation was meticulously documented. The research team updated the model to fix the problems found and improve its usability and clarity based on this helpful feedback.[20]

To gather further opinions and recommendations, the updated model was sent for a second round of expert assessment. The model was further improved and any lingering problems were fixed via this iterative procedure. The completeness and practicality of the model were thoroughly assessed by all specialists in the third and final round of assessment. They concluded the assessment process by agreeing that the approach was both logically sound and relevant to the setting of kids' art education. Figure 1 depicts the review procedure.[21]

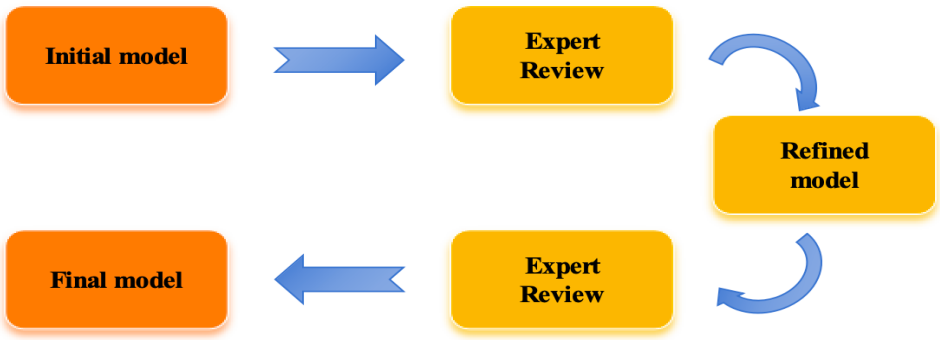

Figure 1. Review process

The purpose of the first round of expert evaluation was to assess the VR museum conceptual model's structure, content, and application while also offering recommendations for improvement. The three stages of the review process—introduction, analysis, and summary—were carried out via online meetings and organised questionnaires.

The model's overarching structure, design goals, main target users (children), and practical applicability in the context of virtual museum-based art learning were initially presented to experts during the introduction phase. The research team elaborated on the theoretical foundation and educational goals of both the technical layer and the design principles layer. Experts were encouraged to raise questions regarding the model's background and design logic to deepen their understanding.[22]

During the analysis phase, experts engaged in an in-depth discussion of the model's structure and content, raising several key issues focused on the logical coherence and educational relevance of various elements, as well as the fluency of the user experience for children. Evaluation priorities included: clarity and completeness of the technical structure (e.g., the Open-Content-Close layout), the effectiveness of design principles (e.g., interface, navigation, multimedia), and the model's capacity to stimulate children's participation, creativity, and autonomous exploration. Experts also discussed the feasibility of implementing the model in both school and extracurricular learning contexts.[5]

In the summary phase, all feedback and suggestions were carefully compiled and reviewed. The main recommendations for improvement included:

(1) Making sure the museum's flow is simple and easy for kids to use; (2) stressing kid-friendly interface and navigation design; (3) elaborating on the target user definition; (4) improving the incorporation of interactive and gamified learning materials; and (5) further honing the iterative development process to facilitate real-world application.

In response to these suggestions, the research team optimized the model based on current literature and best practices. The structural layer was revised to emphasize the "Open–Content–Close" experience, while the interface design was made more streamlined and user-friendly. The relationships among multimedia, interaction, and educational objectives were made visually intuitive in the model diagram. The development process was also updated to include regular feedback from child users and iterative optimization. These revisions ensured the model's logical consistency, practical guidance, and adaptability to real-world scenarios.[23]

Key expert suggestions for optimizing the VR museum conceptual model included:

i) The model should clearly incorporate the actual structural flow of a museum visit to help designers and developers create virtual museum experiences specifically aimed at enhancing children's art learning.

ii) The model should clearly define VR system components suitable for child users, and explicitly describe technical components.

iii) There is a need to further clarify relationships among user groups.

iv) The logical coherence and interconnection among the components of the model need to be more clearly defined and strengthened.

In response to the first suggestion, this study referred to relevant literature on the structural flow of museum exhibitions. According to existing research, the typical museum visit process consists of three parts: introduction, exploration, and conclusion. The introduction presents the exhibition theme and quickly captures the visitor's interest; the content section enables in-depth exploration of artistic material through multimedia displays and interactive activities; and the conclusion reinforces key educational themes and reflection. Additionally, museum design should follow the principles of clarity, educational appropriateness, and engagement. This understanding of structural flow is critical for virtual museum designers and developers, as illustrated in figure 2.

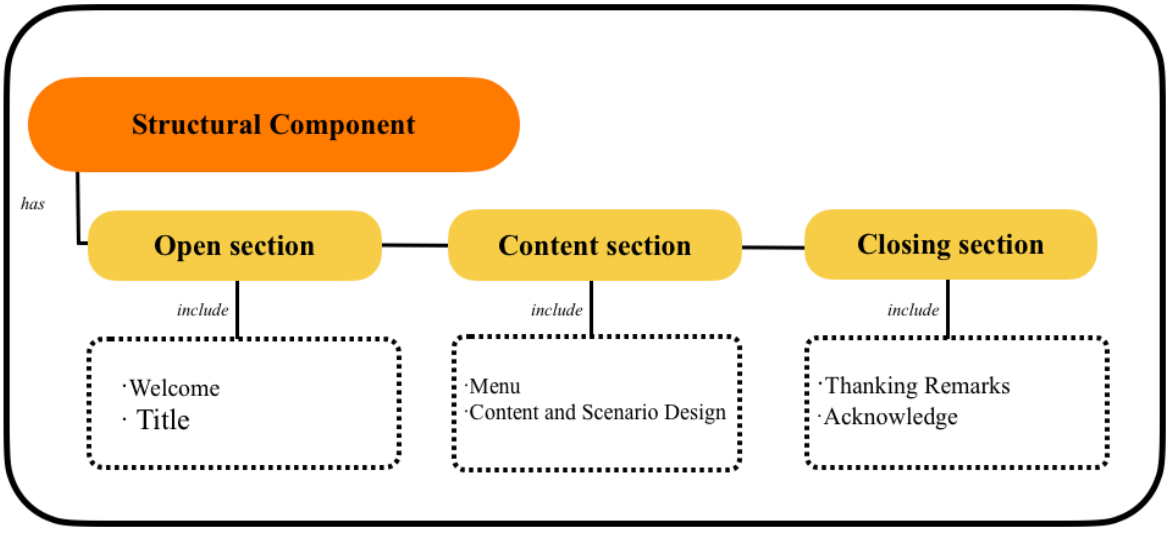

Figure 2. Structure of Model

In response to the second suggestion, the technical component section was confirmed. After clarifying the necessary logic of VR technology, key devices suitable for a children-oriented virtual museum were identified, particularly in terms of visual and auditory functions. The most commonly used visual output device is the Head-Mounted Display (HMD), which provides an immersive visual experience suitable for children. In addition, high-quality headphones offer the required auditory immersion. Therefore, it is recommended that HMDs and headphones be adopted as the primary output devices to enable both visual and auditory interaction R.[3]

Considering that the target users are children aged 7–12, the selected input devices should be simple to operate and age-appropriate. Devices such as VR controllers or handheld joysticks are recommended, as they allow children to intuitively navigate the museum space, select interactive content, and engage with virtual artworks and activities.

In response to the third suggestion, the user group of the model was clearly defined. This project involves the development of a standardized VR design model to guide the creation of virtual museums for children's art education. Based on a comprehensive analysis of existing studies, the proposed design model integrates key

elements of the VR development process. The primary goal of introducing this model is to provide clear guidance for developers to create immersive virtual museum environments specifically designed to enhance children's art learning outcomes. After analyzing multiple relevant studies, this research adopted a systematic design approach previously proposed in the literature, which identifies key target groups in user experience design.

The fourth component is multimedia content. This component clearly defines the multimedia elements within the virtual museum and their interrelationships, which are visually presented using arrows. These elements include 3D models, audio narration, videos, and interactive activities—all specifically designed to create a strong sense of immersion and effectively stimulate children's sensory and emotional engagement. The objective is to promote children's deep understanding and empathy toward cultural and artistic content, aligning with the study's goal of enhancing children's learning experience and cognitive development through immersive virtual museum interaction.[18]

Finally, based on expert feedback regarding the causal relationships among components and suggestions for improving the initial model's process and structure, the model design was reorganized to ensure optimal arrangement of components and elements. This process involved defining the interrelationships among various parts, clarifying their connections to improve clarity and coherence. Figure 3 presents the revised version of the conceptual model of the virtual museum, updated based on the results of the first evaluation cycle.

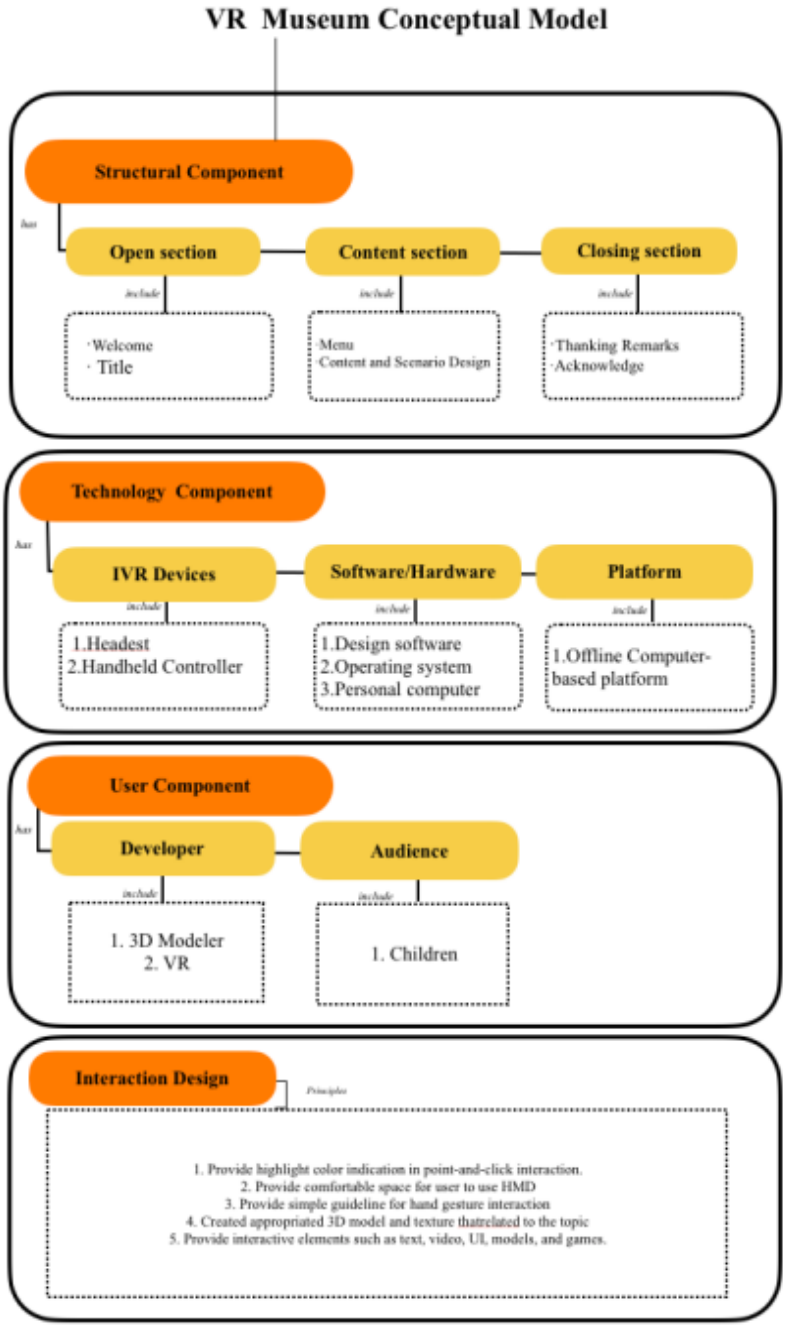

Figure 3. Frist refined model

Second-Round Review

Following the first round, the revised VR museum conceptual model entered the second evaluation round, aimed at identifying remaining issues and proposing new improvements to ensure the model effectively serves children's art learning objectives. This round was conducted through a face-to-face expert meeting.

During the discussion, the research team presented the updated model using multimedia materials and interactive demonstrations. Experts posed questions and offered feedback on the model's design logic, internal structure, and practical application, particularly focusing on the relationships among components and the model's feasibility and effectiveness in real educational settings. Their suggestions targeted the model's core elements, inter-element relationships, and overall usability in children's contexts (table 4).

Based on this feedback, the model was further refined, with special emphasis on interactive participation and empathic development within the virtual museum environment. Drawing from the latest studies, social interaction and emotional resonance mechanisms were explicitly included as core components for creating immersive learning experiences. These features were clearly strengthened and integrated into the model structure.[24]

To improve conceptual clarity, the overall structure was revised to make logical connections between components more transparent and intuitive, significantly improving the model's coherence and usability.

Additionally, based on expert feedback, some elements were further refined, integrated, or expanded. For example, the design components and multimedia elements were clarified and highlighted. Moreover, logical flows in the model were further detailed, and concise definitions were provided for each term to enhance understanding and support practical application.[25]

Table 4. Expertsexperts review

Expert	Comments
A	(1) The technical roadmap is reasonable and feasible, but lacks an implementation path module. (2) The model's process and structure need further optimization to ensure clearer logical relationships among components.
B	(1) Avoid excessive functional complexity during implementation; focus on a few key features. (2) Considering the specialized knowledge involved in the design, an offline deployment model is recommended.
C	(1) The overall logic of the current model is relatively weak and needs to be restructured. (2) Each process line in the model must have clear labels and corresponding explanations.
D	(1) The overall technical process is reasonable and the structure is clear. (2) Strengthen user experience design thinking. Since the thesis focuses on "the effectiveness of virtual museums in children's art learning," the user group—children—must be further reflected in the model structure through relevant design principles.
E	(1) Re-examine the main components, elements, and principles to ensure consistency with the research background. (2) Clearly define the type of model you have chosen (CVR/IVR). If it is conventional VR or immersive VR, the model components should match the specific VR form.
F	(1) Integrate specific components required for museum functionality. (2) Distinguish between components used for PC-based platforms and those for immersive VR platforms.
G	(1) Find relevant literature to support your virtual museum development plan and refer to practices in physical museums. (2) Clearly indicate the type of virtual reality design selected—whether immersive VR (IVR), online or offline, immersive or non-immersive. (3) Summarize your virtual museum design elements, especially by classifying and organizing them according to the proposed components and elements.

Figure 4 shows the revised model based on suggestions from the second evaluation round.

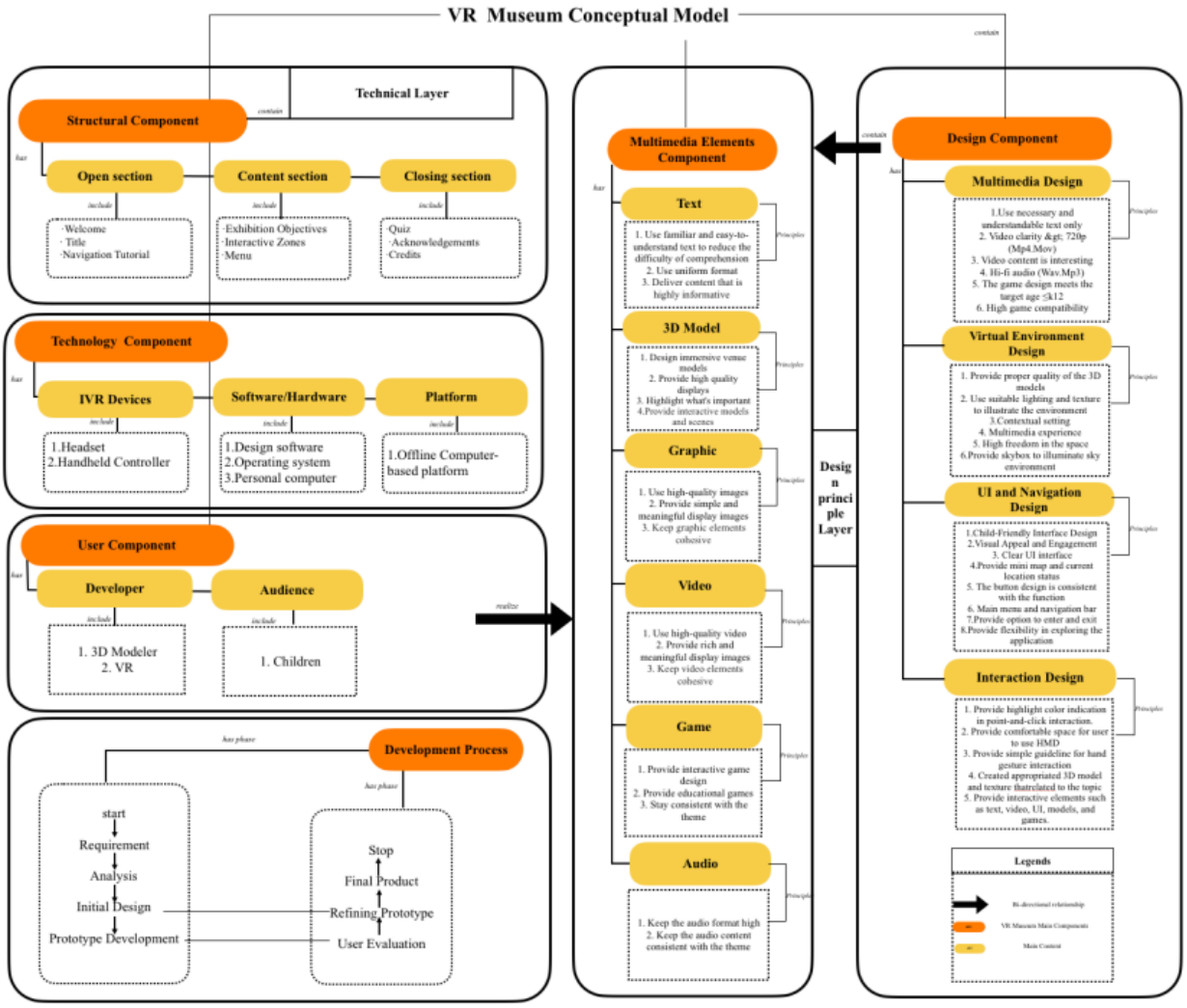

Figure 4. Second refined model

Cycle Three

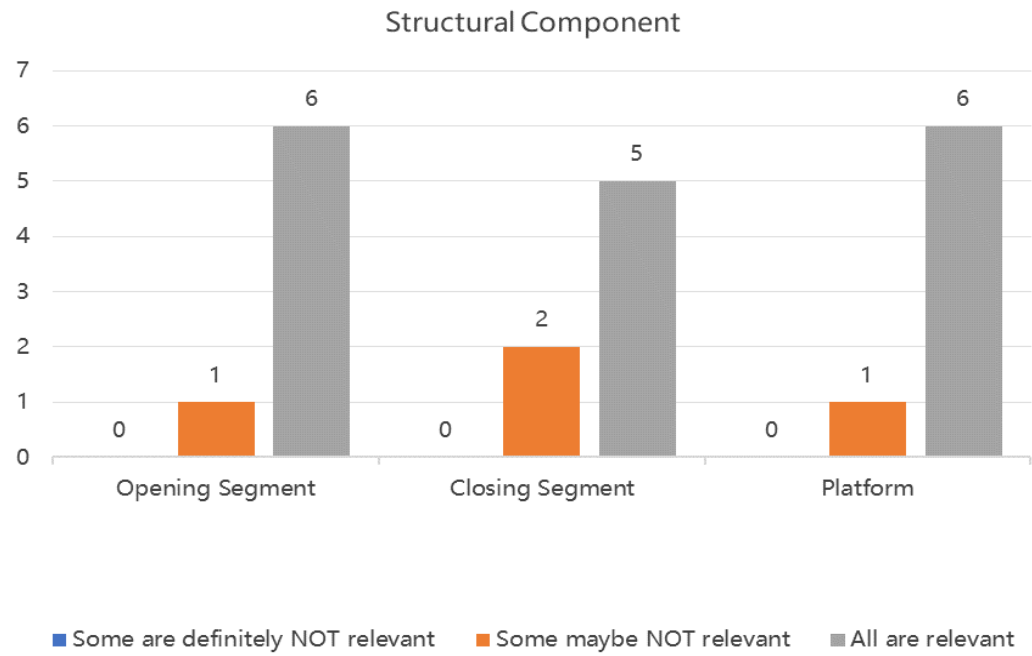

Figure 5. Structural Component

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In this cycle, the second refined model underwent further expert evaluation. As in the previous cycle, the objective was to identify any remaining deficiencies in the proposed model and make further improvements.

The expert reviewers provided many insightful suggestions for the conceptual model of the virtual reality museum. As shown in figures 5–10, the data indicate that most experts generally agreed on the relevance of the six main components proposed in the conceptual model, along with their respective sub-elements. Except for certain design principles such as the multimedia elements and the development process component, the remaining design criteria were regarded as educationally adaptable and practically valuable.[26] Most experts stated that the design principles were clearly articulated and easy to understand, with only a few suggesting further clarification regarding game difficulty levels and adaptability in technical development. Additionally, the terminology clarity, logical structure, and readability of the model's components were highly affirmed by the experts, as shown in figure 11.

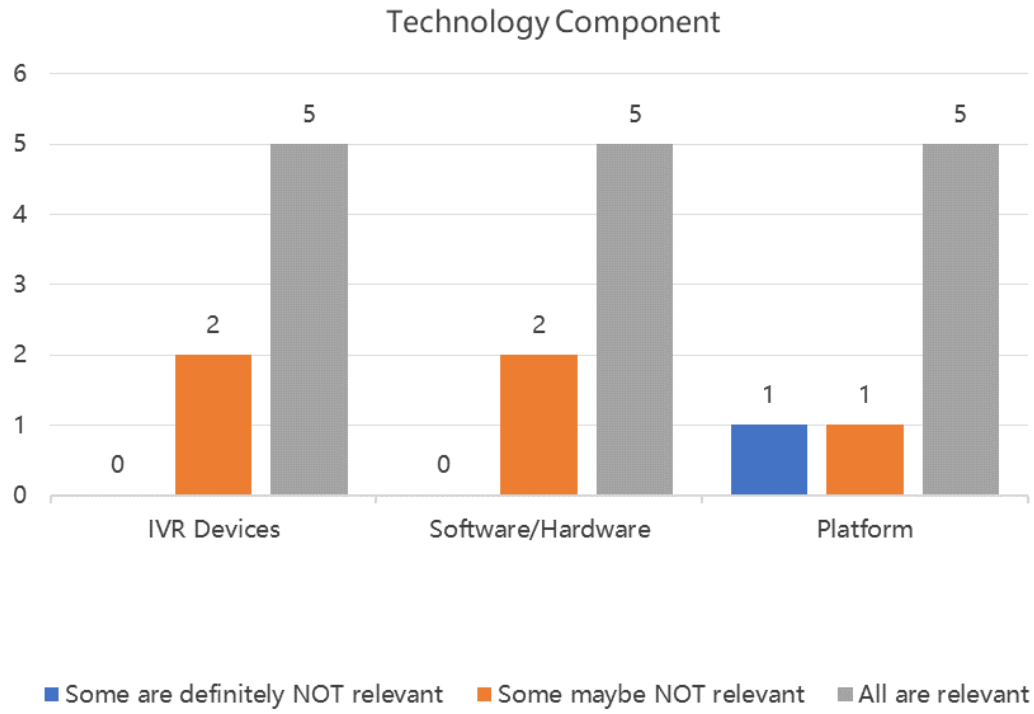

Figure 6. Technology Component

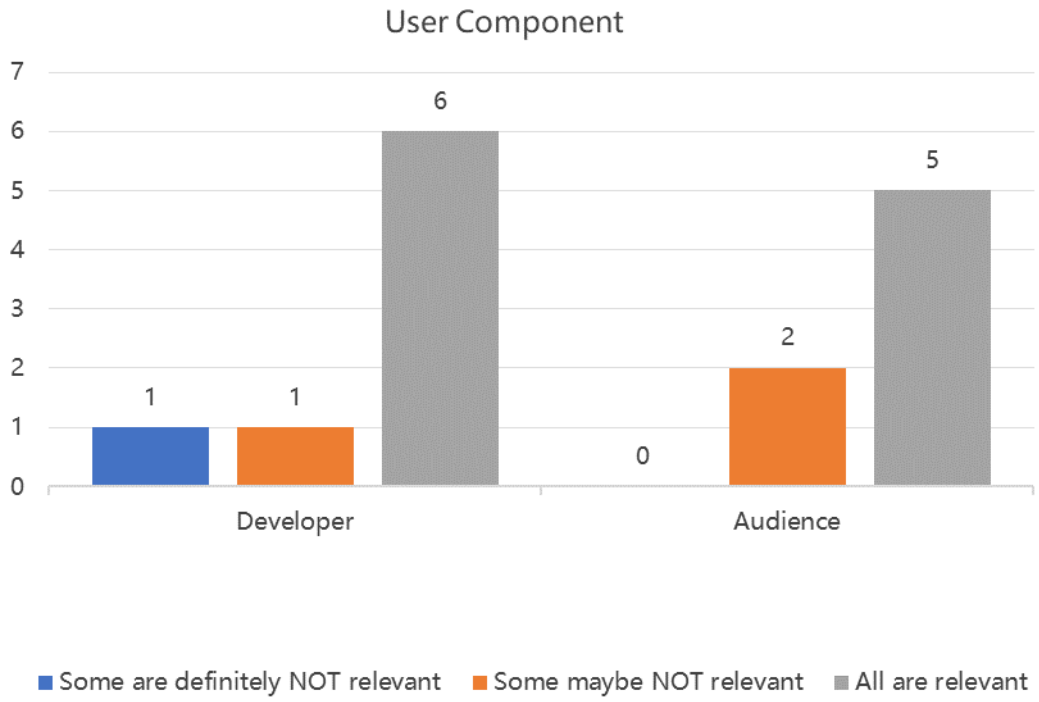

Figure 7. User Component

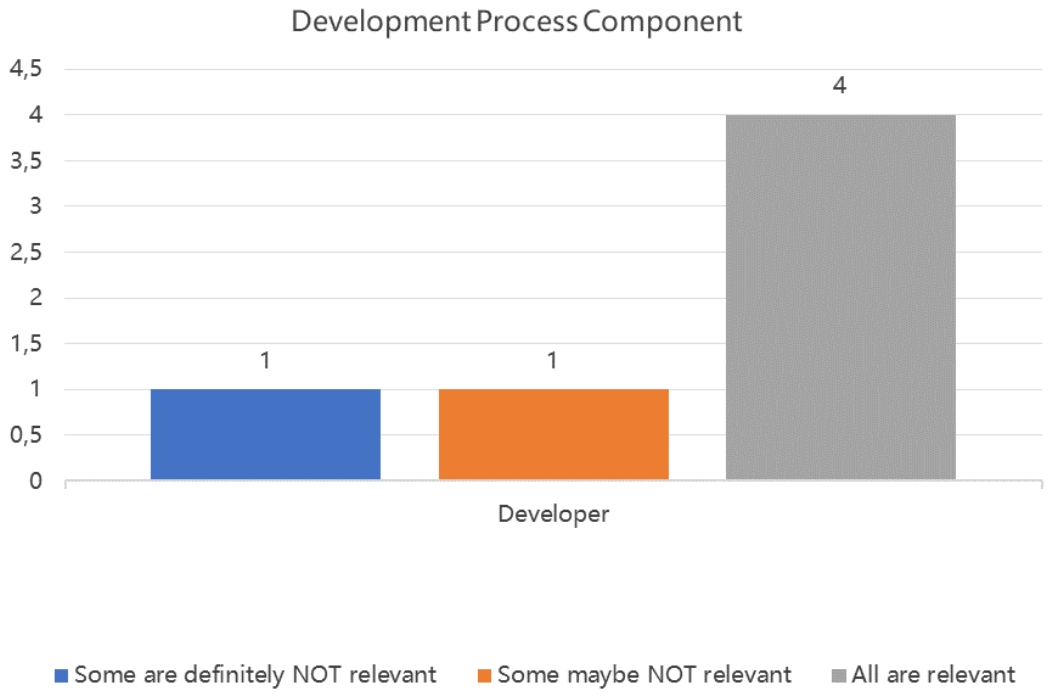

Figure 8. Development Process Component

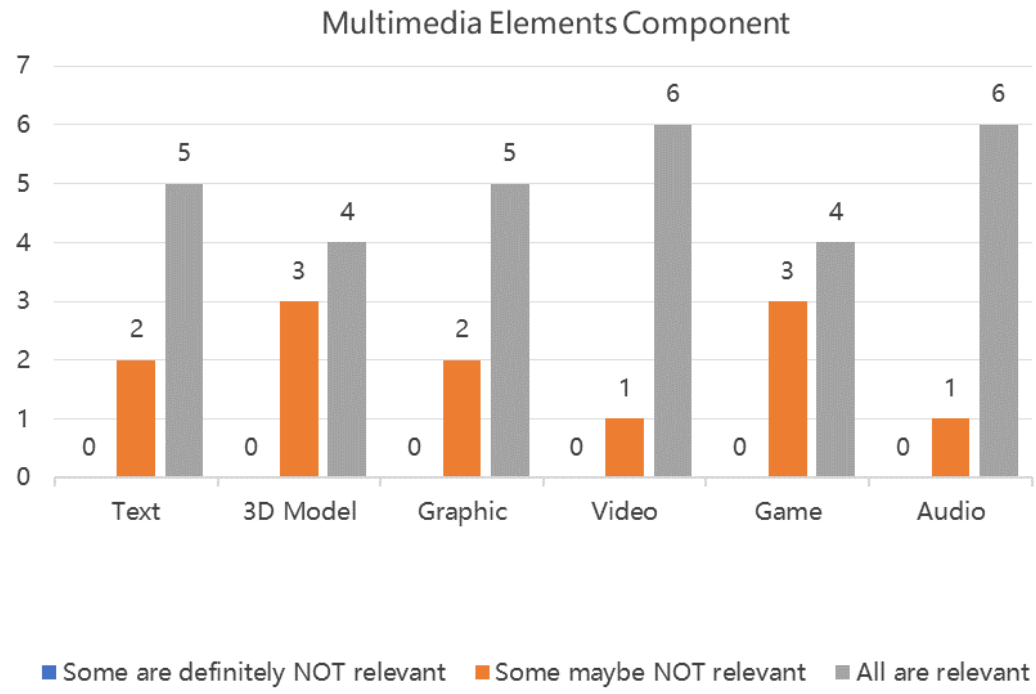

Figure 9. Multimedia Elements Component

Based on expert feedback, the research team conducted multiple rounds of revision and refinement of the virtual museum conceptual model until all experts fully endorsed the final version.

After a final round of review, the experts unanimously agreed that the revised model not only features a clearer structure but also provides actionable design and implementation guidance for real-world applications. Therefore, this model has been confirmed as the final framework of the study.[2]

Next, the research team will use this model as the foundation to guide the development team in building a prototype virtual museum system and conduct further empirical research to evaluate its feasibility and effectiveness. The related research findings will be systematically summarized and published in subsequent academic papers.

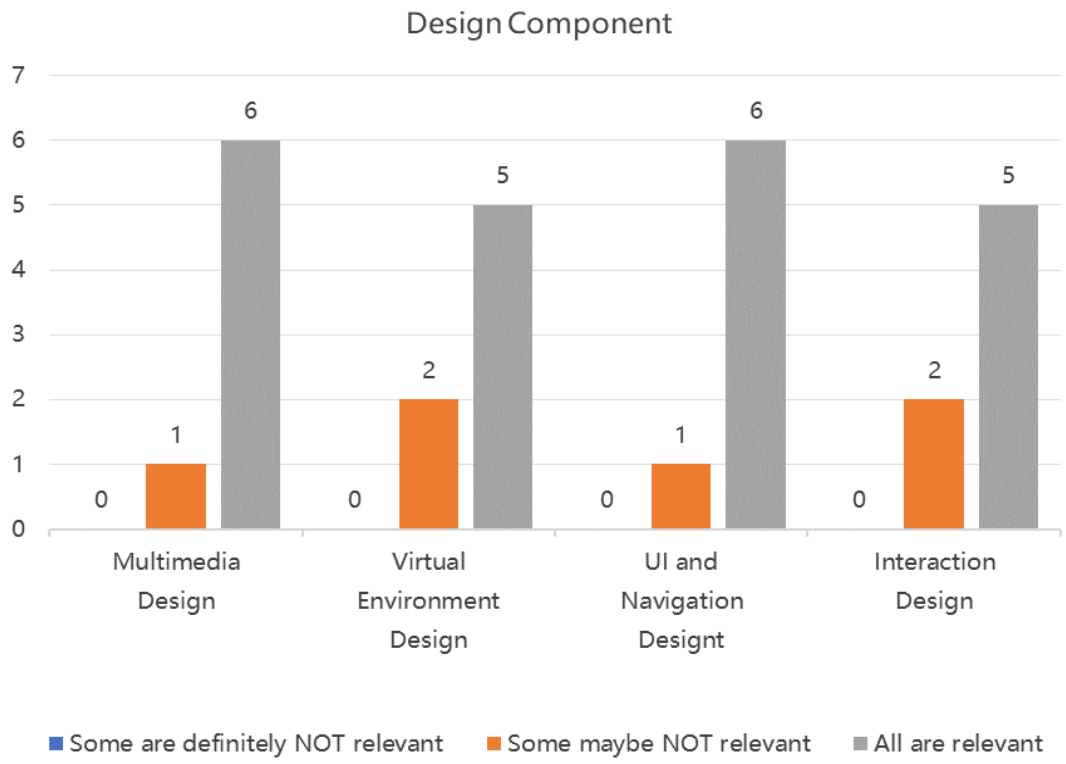

Figure 10. Design Component

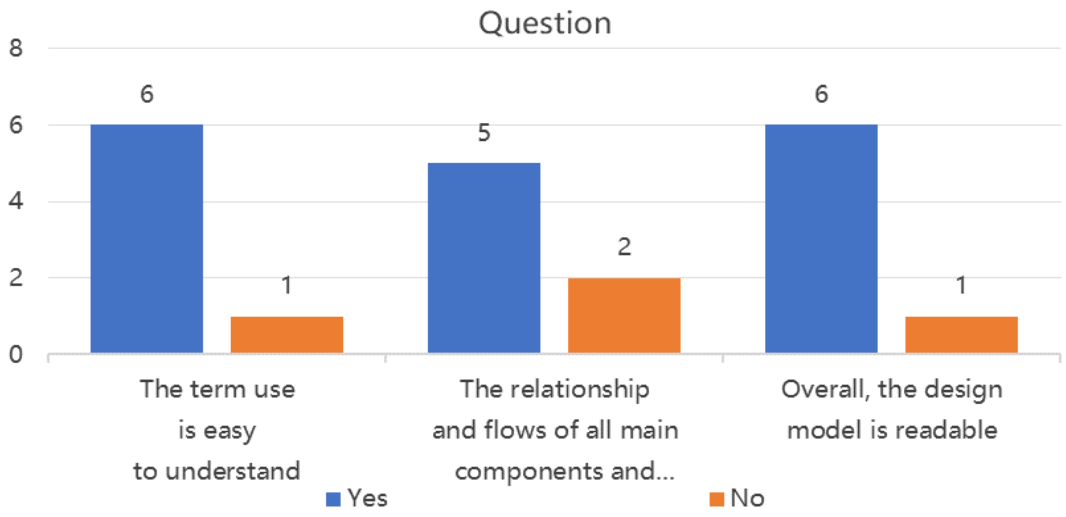

Figure 11. Clarity of Terminology, Logical Structure, and Readability of the Model

DISCUSSION

This study, grounded in virtual reality technology and educational theory, proposed a conceptual model of a virtual museum designed for children's art learning. The model systematically integrates key structural components, design principles, and development guidelines involved in the development of virtual museums, aiming to create an efficient and immersive art learning experience for children. The strategy, which is based on immersive interaction and multimedia material, helps kids become more engaged, creative, and cognitively mature. After three rounds of expert assessments, most experts confirmed that the model is conceptually sound, has high potential for practical use, and is structurally solid. Expert input has also yielded insightful recommendations for further model optimization and improvement.

However, there are certain restrictions on this research. First, there has been no empirical assessment of the model's efficacy involving actual kid users; instead, it has only been evaluated subjectively by professionals. As a result, real-world application is still required to confirm the model's true influence on raising learning outcomes and engagement. Second, the study primarily focuses on the conceptual design and theoretical development of the model, without fully addressing its adaptability across different educational settings,

technological platforms, or cultural contexts.

As such, although the proposed conceptual model demonstrates initial theoretical validity and has received expert consensus, it should essentially be regarded as an open and expandable research framework. Future work should focus on developing a functional prototype of the virtual museum based on this model and empirically evaluating its effectiveness in enhancing children's engagement in art learning and promoting creative thinking within real educational environments.

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