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# Design of AR Content for Improving Artifact-centered Contextual Learning of Processional Paintings

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**Keywords:** Augmented Reality, Interactive Museum Experience, Processional Painting, Artifact-centered Design, Spatial Narrative.

**Abstract**

In the utilization of digital cultural heritage content, several studies have raised concerns regarding the potential erosion of authenticity inherent in artifacts and the prioritization of entertainment. Existing digital content related to processional paintings exhibited in museums particularly focuses on visual effects utilizing large screens or projection mapping, which presents limitations in fully conveying the historical narratives embedded within the artworks. Furthermore, such experiences tend to remain content-centric and are detached from direct engagement with original artifacts. Accordingly, this paper proposes an artifact-centered augmented reality (AR) design framework that enhances contextual learning through the *Hwaneohaengneoldo* from the *Hwaseonghaenghaengdo* folding screen, which depicts King *Jeongjo*'s royal procession to *Hwaseong* Fortress in 1795. The proposed content is designed with a sequential three-stage structure: (1) providing fundamental artwork information, (2) connecting past processional routes with contemporary geographical spaces, and (3) multi-marker-based AR experiences. Grounded in contextual learning theory, this approach connects the cognitive contexts of present-day visitors with historical narratives, facilitating intuitive and concrete understanding. Experimental results show excellent evaluations in artifact-content connectivity and contextual learning effectiveness. The learning pathway of geographical connection → concrete cognition → value recognition was statistically validated, and correlations between artifact connectivity and user engagement were confirmed. Through this design, users move beyond simple audiovisual experiences by learning contextual elements through interaction. By integrating digital content with original artifact appreciation, this approach enhances understanding while maintaining authenticity and historical context.

## 1. Introduction

With the rapid development and proliferation of digital technology during the Fourth Industrial Revolution, the cultural heritage sector has also adopted and utilized digital technologies across multiple dimensions. The International Council of Museums (ICOM) newly defined museums at the ICOM General Assembly held in Prague, Czech Republic in 2022 as follows: "A museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage. Open to the public, accessible and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection and knowledge sharing." While traditional museum definitions focused on institutions as places for collecting, preserving, storing, and exhibiting cultural heritage, contemporary museums are transformed into spaces where visitors can experience emotionally stimulating and memorable encounters (Bellio et al., 2024). Modern museums, emphasizing user-centered approaches and meaningful public experiences, are planning diverse exhibitions as public-friendly spaces. Within this transformation, exhibition media utilizing digital technology contribute to the new social role of museums by enhancing visitor interest and providing diverse experiences.

However, several studies have raised concerns from critical perspectives regarding museums' use of digital technology. Museum professionals have expressed concerns about the risk of Disneyfication, where museum authenticity becomes overshadowed by entertainment value (Nikolaou, 2024; Komarac et al., 2019). As digital technology becomes emphasized, visitor experiences may shift toward content-centricity, potentially weakening relative interest in original artifacts. While museums' adoption of digital technology represents an inevitable trend, digital technology is not merely a tool, but an element deeply connected to the values and identity that museums possess (Nikolaou, 2024). Previous research has categorized museum authenticity into three types: objective authenticity corresponding to original artifacts themselves, constructive authenticity based on social consensus of visitors experiencing objects, and existential authenticity concerned with whether the visitors' own experience is authentic (Wang, 1999). Within this context, digital cultural heritage content should be utilized to preserve objective authenticity in museum experiences by maintaining visitor interest in original artifacts. Simultaneously, it should aim to preserve existential authenticity by providing meaningful experiences with artifacts.

Meanwhile, painting heritage presents several considerations for content development depending on its type. High-context painting heritage such as historical paintings, religious paintings, and court documentary paintings possesses characteristics that condense multilayered contexts and complex historical events across time and space within a single composition (Ham, 2022). With numerous figures and objects depicted in complex arrangements, elements within artworks are not immediately comprehensible, and without knowledge of the roles and cultural symbolism these elements possess, complete understanding of paintings becomes challenging. For example, in the case of processional paintings, while actual processions include various spatial backgrounds and narratives, the paintings depict only selected scenes, which may cause distortions. As a result, it is difficult for viewers to understand the embedded context through visual observation alone. Therefore, supplementary explanations are essential for audiences to properly understand the content and value contained within paintings.

Processional paintings are artworks depicting processions primarily created in Korea and other East Asian regions, serving as typical examples of high-context documentary paintings. Particularly, the *Hwaneohaengneoldo* from the *Hwaseonghaenghaengdo* folding screen—a Joseon Dynasty painting depicting King *Jeongjo*'s complex 1795 *Hwaseong* procession—represents a paradigmatic case. In this artwork, both the authenticity challenges of museum digital technology and the contextual understanding issues inherent in high-context painting heritage are evident. However, current digital content based on processional paintings predominantly consists of content utilizing large media screens and projection mapping, with limitations including an overemphasis audiovisual appreciation experience, providing experiences separated from original artifacts, and inadequate contextual learning information provision.

Accordingly, this paper focuses on the *Hwaneohaengneoldo*, a Joseon Dynasty painting heritage, with the following primary objectives: (1) To propose an artifact-centered AR content design method that offers meaningful experiences to visitors by supporting engagement with the original artifact based on objective authenticity, and (2) To establish multilayered learning environments that connect the multilayered historical narratives and compositional elements of the *Hwaneo haengneoldo* with the cognitive contexts of contemporary viewers, thereby facilitating intuitive and concrete understanding. Additionally, through comparative evaluation with existing processional painting projection mapping content, we seek to empirically analyze the effectiveness of the proposed approach.

The paper structure is as follows: Chapter 2 reviews previous research on digital content for painting heritage; Chapter 3 presents the proposed AR content design methodology; Chapters 4 and 5 present user experimental evaluation and conclusions and future work, respectively.

## 2. Related Work

### 2.1 Digital Content Approaches for Painting Heritage

Various digital technology approaches including projection mapping, interactive technology, and AR have been utilized for high-context painting heritage. These technologies support appreciation and understanding of painting works containing complex narratives and symbolism, each possessing unique advantages and limitations according to their technological characteristics.

Projection mapping-based content specializes in providing emotional experiences through large-scale spatial immersion. The National Museum of Korea's Immersive Digital Gallery 1 utilizes a 60-meter-wide, 5-meter-high panoramic screen to display video content targeting various painting works including landscape paintings, religious paintings, and documentary paintings (National Museum of Korea, 2025). Through spatial characteristics consisting of three-sided large screens, it maximizes visitors' sensory and emotional experiences, providing vivid and immersive appreciation experiences. The National Palace Museum of Korea's "Immersive *Hwaseong*" exhibition screened 3-minute projection mapping content targeting the *Hwaneohaengneoldo*, which is also the subject of this paper. Characters and objects within processional paintings are created as 3D assets and animated, emphasizing core elements including King *Jeongjo*, Queen Dowager *Hyegyeonggoong*, and *Siheung* temporary palace while providing simple explanations to deliver information about narrative content and embedded values within paintings (Interactive Digital Heritage Lab, 2025). However, these media art contents inherently focus on emotional experiences through spatial immersion, making separation between content and original artifact appreciation inevitable, and demonstrating limitations in terms of insufficient information provision to aid understanding of target artifacts.

Technologies such as touchscreens or interactive web provide environments where users can explore detailed elements of painting works through active participation. The National Museum of Korea's "Into a Peaceful Day, *Taepyeongseongsido*" presents an 8-panel folding screen implemented in 8K resolution on an 8.5-meter touchscreen, enabling detailed appreciation through 16 types of interactive events where visitors directly interact with elements within paintings. Through animations showing daily life within the castle according to temporal flow, narrative content within paintings is visually implemented (National Museum of Korea, 2025). The Rijksmuseum's interactive web content demonstrates more systematic approaches. "Closer to Johannes Vermeer" provides ultra-high-resolution images of 5 micrometers per pixel, constructing thematic content enabling comparative appreciation by selecting commonly used elements across Vermeer paintings such as pearls, yellow clothing, and curtains (Rijksmuseum, 2023). "Experience the Night Watch" is designed to enable thematic appreciation by selecting elements such as characters, painting characteristics, and hidden symbols from Rembrandt's "The Night Watch" (Rijksmuseum, 2019). These contents provide elements contained in painting works along with related narratives and background information, supporting comprehensive learning about target works and overall culture. However, these contents also essentially fail to ensure appreciation of the original artifacts, limiting them to indirect experiences through digital media.

### 2.2 AR Contents in Painting Heritage

AR technology enables the integration of real-world environments with virtual objects in real-time, providing the potential to support both original artifact appreciation and digital content experiences simultaneously. This characteristic is being used for learning purposes in various museum domains (Zhou et al., 2022). The Diocesan Museum of Milan's religious painting AR guide provides marker-based AR content that includes videos explaining painting meanings and interactive interfaces for characters, gestures, and objects. It provides integrated connections with related artifacts within museums, exploration through 3D models, and opinion exchange functions among users (Greci, 2016). The Latvian National Museum's Overly AR application provides detailed information about artworks to museum visitors. Beyond general artwork descriptions, when users select specific portions of paintings, they can view enlarged images and textual explanations of those sections (Yılmaz and Apilioğulları, 2021). China's "Along the River during the Qingming Festival" AR content demonstrates more advanced technological approaches. Elements within paintings were created as 3D assets and configured into 3D environments, implemented for tablet-based appreciation. After marker recognition, the painting environment is rendered in 3D on full screens. When specific objects are selected, only the corresponding objects are augmented, and related explanations are provided in text format (Gong et al., 2022). This supports immersive experiences through 3D environmental visualization and object descriptions, but remains limited to fragmentary

experiences of individual objects rather than comprehensive narrative and contextual learning about paintings.

These various AR contents provide interactive learning experiences through integration of original artifacts and digital information, but generally possess limitations in concentrating on explanation support for elements within artworks.

## 3. Methodology

### 3.1 Target Painting: *Hwaneohaengneoldo*

Figure 1. *Hwaneohaengneoldo* © National Palace Museum of Korea, 2025

The *Hwaseonghaenghaengdo*, a court documentary painting, records the eight-day royal procession undertaken by King *Jeongjo* in 1795. This procession was to pay respects at *Hyeollyungwon* in *Hwaseong*, commemorating the 60th birthdays of his father, Crown Prince Sado, and his mother, Queen Dowager *Hyegyeonggoong*. This eight-panel folding screen depicts eight different subjects: *Hwaseongseong myojeonbaedo*, *Nangnamheonbangbangdo*, *Bongsudangjinchan do*, *Nangnamheonyangnoyeondo*, *Seojangdaeyajodo*, *Deukjung jeongeosado*, *Hwaneohaengneoldo*, and *Hangangjugyohwan eodo*. Each panel measures 77.5 cm in width and 216.8 cm in height. Multiple folding screens with identical themes were produced. They are currently housed in the National Palace Museum of Korea, National Museum of Korea, and Leeum, Samsung Museum of Art (one copy is at each institution), with individual panels collected at Dongguk University Museum, The Museum of Kyoto University in Japan, and Tokyo University of the Arts (National Palace Museum of Korea, 2025). This paper focuses on the version housed in the National Palace Museum of Korea.

Among these, the *Hwaneohaengneoldo* is the seventh panel, depicting the scene where King *Jeongjo*'s royal procession, departing from Suwon on the seventh day of the journey on the 15th day of the intercalary second month, arrives at *Siheung* temporary palace while returning to the capital. This painting is depicted with such realism that the arrangement of the royal procession nearly matches when compared with documentary records like the *Hwaseongwonhaengbanchado* stored in *Kyujanggak*. Hundreds of procession members and various objects are arranged according to a precise hierarchy and order, vividly demonstrating the actual appearance of *Joseon* Dynasty royal processions. Notably, it depicts a scene where *Jeongjo* halts the procession and sets up temporary arrangements to offer rice porridge to his mother, Queen Dowager *Hyegyeonggoong*. This symbolically illustrates that the *Eulmyo* year procession originated from his filial devotion. In the painting, *Siheung* temporary palace and the location where rice porridge offerings took place are approximately 4.3km apart, positioned together within a single scene. This intentional spatial composition visually emphasizes the special significance of both locations (Ko et al., 2013).

The *Hwaneohaengneoldo* thus represents an artwork where *Jeongjo*'s filial devotion and political intentions are complexly expressed through realistic depiction and symbolic spatial composition. However, the roles and meanings of individual figures and the historical contexts of processional routes remain difficult to fully comprehend through simple visual appreciation alone. This makes the painting an ideal subject for contextual learning content using digital technology.

### 3.2 Proposed AR Content and Its Architecture

**3.2.1 Design Concept**: This paper is based on the following guiding concepts for artifact-centered augmented reality content design. First, the system is designed to provide integrated experiences where digital content remains inseparable from original artifacts. Using multiple markers, users are required to observe the composition and elements of original artifacts to locate corresponding marker areas, ensuring an experience of objective authenticity during the content engagement process.

Additionally, contextual learning theory is applied as the core theoretical foundation of this content. According to contextual learning theory, human understanding and memory are more effectively achieved when information is connected to familiar contexts rather than presented as isolated data (Bransford et al., 2000). Accordingly, contemporary places that users can intuitively recognize within the context of their present era are utilized as existing schemas, with route experience structures designed to connect historical narratives to these locations, enabling users to perceive abstract historical information as concrete events. By connecting past processional routes with present-day regions to enable intuitive understanding of *Jeongjo*'s return journey, the system facilitates cognition of historical events through connection with users' current environmental contexts, transcending simple information transmission.

Furthermore, detailed information provision regarding individual components supports understanding of artwork details by offering explanatory content about ceremonial objects, character roles, and other elements. By enabling users to learn the roles and symbolic meanings of individual figures and objects, the system supports multilayered and comprehensive understanding of the artwork while simultaneously enhancing cultural heritage literacy of the overall culture within the broader contextual framework of the *Joseon* Dynasty.

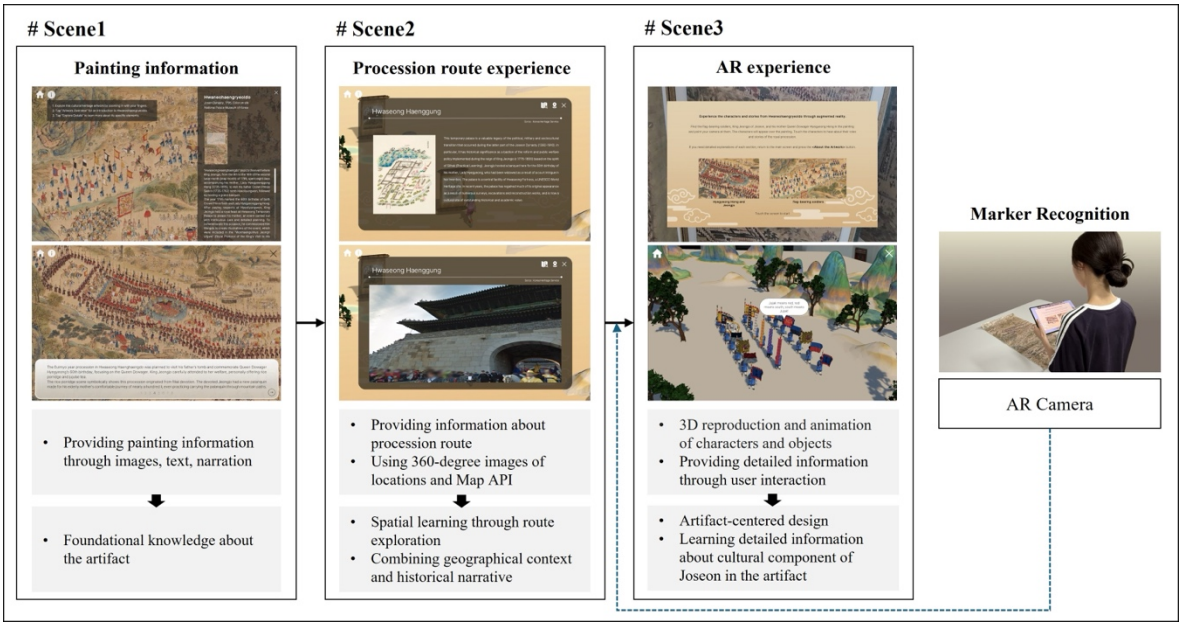



Figure 2. Proposed an architecture of AR content.

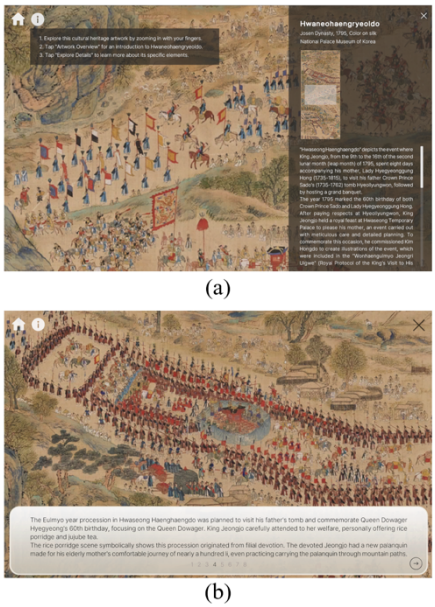
**3.2.2 Content Architecture**: The system is designed with a sequential three-stage structure. The first stage, Painting information, offers fundamental information about the *Hwaneohaengneoldo* and supports users' free observation. In this stage, users establish foundations for proceeding to subsequent stages based on sufficient understanding of original artworks. The second stage, Procession route experience, provides spatial contextual learning based on actual processional routes, supporting educational experiences that connect past historical events with present geographical spaces. The final AR experience stage supports advanced learning regarding elements within paintings through marker-based interaction, allowing users to experience digital information while simultaneously observing original paintings.

Marker areas for AR experiences are selected considering educational effectiveness and historical significance. The palanquin section of Queen Dowager *Hyegyeonggoong* represents the core scene where *Jeongjo*'s filial devotion is intensively revealed, deemed most suitable for conveying the essential meaning of the *Eulmyo* year procession. The flag-bearer sections are selected as areas where users can effectively learn the hierarchical order of royal processions and the symbolic meanings of individual figures and objects. The overall design structure is illustrated in Figure 2.

### 3.3 Content Implementation

**3.3.1 System Development**: The system hardware utilizes Samsung Galaxy Tab S8 Ultra, while software is developed based on Unity 3D engine version 2022.3.33f1. For AR functionality implementation, a multi-marker recognition system is constructed utilizing Vuforia SDK, and for geographic information integration, the V-World application programming interface (API) operated by the Ministry of Land, Infrastructure and Transport of the Republic of Korea is selected. V-World provides accurate and reliable geographic information based on national standards, ensuring the accuracy of spatial information essential for contextual learning through connections between past processional routes and present spaces. These technological choices create an active learning environment through user-driven exploration and discovery, while delivering immersive experiences that support real-time multimedia interaction.

**3.3.2 Detail of Content**:




(a)

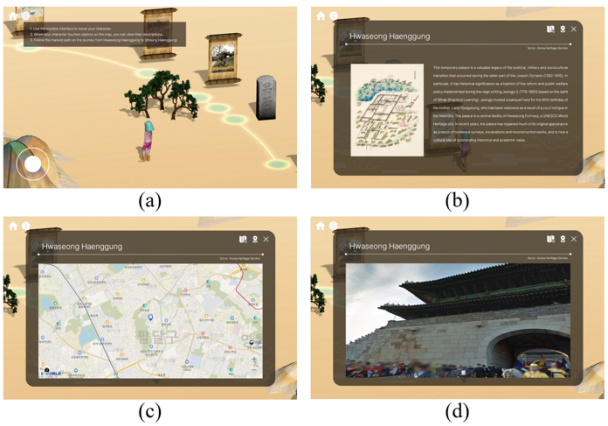
(b)

Figure 3. Interface of painting information: (a) fundamental artwork information and free appreciation, (b) automatic explanation function.

The main screen of the content consists of 'About the Artwork' and 'Start the Experience' buttons. Tapping the first button transitions the user to the Painting Information scene, where fundamental information about the *Hwaneohaengneoldo* including production year, content, and dimensions is provided through panel, enabling free magnification and reduction of the painting through pinch gestures. As shown in Figure 3, a mini map is provided to help users identify their current viewing area within the entire painting, supporting comprehensive exploration. Tapping the automatic explanation button triggers automatic magnification of corresponding sections along with explanations provided in the lower panel, facilitating understanding of the painting's composition and historical context.

Since the *Hwaneohaengneoldo* depicts a specific moment when the procession arrives at *Siheung* temporary palace, understanding the actual processional narrative information presents difficulties. Accordingly, information related to the locations traversed by the procession is provided to facilitate learning of historical narratives and detailed information. The processional route is constructed based on the *Wonhaengeulmyojeongniuigwe* and related scholarly materials, and major spots with high educational value are selected from locations currently utilized in *Hwaseong* procession reenactment events to emphasize the connectivity between past and present. Player characters and objects corresponding to each major spot are positioned on a 3D plane, and users can move characters by manipulating joystick user interface (UI) on the tablet.

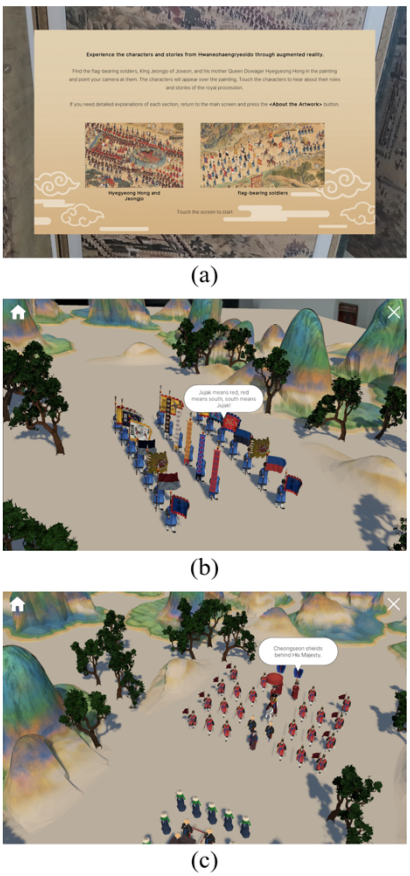
The system is designed so that collision between user characters and each object triggers appearance of explanatory UI windows for corresponding locations. Explanatory User Interface windows fundamentally provide photographs and textual descriptions of locations, with map buttons at the top enabling viewing of current maps of corresponding locations. GPS coordinate values corresponding to each spot are assigned within Unity to display maps centered on corresponding spots, with locations clearly distinguished visually through marker emphasis. Utilizing topographic and satellite map functions, users can select map types according to need, with button UI controls enabling map movement and magnification/reduction. Tapping panorama buttons at the top enables appreciation of 360-degree panoramic images of corresponding locations downloaded from Google Street View and created as materials within Unity. This enables direct comparative experiences between past processional routes and present landscapes, as demonstrated in Figure 4.




(a) (b) (c) (d)

Figure 4. Procession route experience Interface: (a) overall view of processional route experience, (b) fundamental descriptions of processional route locations, (c) maps with location markers, (d) 360-degree images.

Upon reaching the *Siheung* temporary palace object, the destination of the procession in the route experience section, transition occurs to the AR experience section. The core of the AR section lies in providing immersive learning experiences through historically accurate 3D models. For this purpose, systematic verification processes were conducted through expert consultation, referencing related literature including *Wonhaengeulmyojeongniuigwe*, *Hwaseongseongyeoguigwe*, and *Gisajinpyoriuigwe*. For painting materials, *Hwaseong wonhaengbanchado* and *Wonhaengjeongniuigwedo* were utilized for cross-verification of visual information. For verification of costumes and objects, comprehensive analysis was conducted of *Uigwe* diagrams, transmitted artifacts, excavated artifacts, and photographic materials, with visualization work proceeding through integrated analysis and verification of various literature, paintings, and artifact materials using the National Palace Museum of Korea collection as the standard text. Particularly regarding character placement, careful composition was undertaken based on *Banchado* to conform to historical facts.



(a) (b) (c)

Figure 5. AR experience Interface: (a) marker presentation for user recognition, (b) flag bearer area augmentation, (c) *Jeongjo* and *Hyegyeonggoong* area augmentation.

As shown in Figure 5, when users recognize corresponding markers through tablet cameras, 3D content becomes augmented, and touching augmented characters triggers appearance of speech bubbles and audio commentary explaining roles of corresponding figures or symbols and meanings of ceremonial items. Through this, users can learn symbolic and cultural meanings possessed by each component, transcending simple audiovisual experiences. This facilitates multilayered and comprehensive understanding of artworks while contributing to enhancement of comprehensive cultural literacy within the broader context of the *Joseon* Dynasty. Audio commentary scripts were written based on verified historical contexts and produced utilizing Text-to-Speech (TTS) technology. Particularly when touching the palanquin of Queen Dowager *Hyegyeonggoong*, a scene where temporary dining space is prepared for her to consume rice porridge is specially staged. During this moment, walking animations of characters halt, dialogue changes, and erected tents appear on screen to emphasize events depicted in the painting, implementing storytelling that highlights *Jeongjo*'s filial devotion.

## 4. Experimental Results

### 4.1 Experimental Design

A comparative experiment is designed to evaluate the effectiveness of the proposed artifact-centered AR content. The experiment is conducted targeting two digital content pieces created based on the same subject, the *Hwaneohaengneoldo*. The projection mapping content screens at the National Palace Museum of Korea's "Immersive *Hwaseong*" exhibition is selected as the comparison target. A total of 22 participants in their 20s and 30s participated in the experiment. The evaluation instruments consisted of quantitative questionnaires using 5-point Likert scales and qualitative evaluation forms including descriptive questions. For the purpose of this paper, the questionnaire was divided into four factors: Artifact Connectivity, Contextual Learning Effectiveness, User Engagement, and Experience Satisfaction. As shown in Table 1, each factor included three detailed items, totaling 12 questions.

| Factors | | Questionnaire Items |
|---|---|---|
| Artifact Connectivity | Q1 | The content experience enhanced my understanding of the artifact. |
| | Q2 | The content experience improved my recognition of the historical and cultural value of the artifact. |
| | Q3 | The content experience enhanced my observation, appreciation, and immersion in the original artifact. |
| Contextual Learning Effectiveness | Q4 | Historical events felt concrete rather than abstract. |
| | Q5 | I was able to understand the connection between contemporary geographical contexts and historical routes. |
| | Q6 | Understanding of *Joseon* Dynasty culture deepened through learning about the roles and symbolism of figures and objects. |
| User Engagement | Q7 | I was able to maintain focus and concentrate on the content. |
| | Q8 | I found the content engaging and interesting. |
| | Q9 | I lost track of time while experiencing the content. |
| Experience Satisfaction | Q10 | I was satisfied with the overall content experience. |
| | Q11 | I would like to experience similar cultural heritage content in the future. |
| | Q12 | I would recommend this content to others. |

Table 1. Questionnaire items of content experiment.

### 4.2 Results and Discussion

Comparative experiment results between the proposed AR content and existing projection mapping content demonstrate that AR content shows superior performance overall. In factor-wise mean comparisons, AR content records higher scores than projection mapping content in all evaluation factors. Particularly significant differences are observed in Artifact Connectivity (AR: 4.8, Video: 3.6), Contextual Learning Effectiveness (AR: 4.6, Video: 3.2), and User Engagement (AR: 4.5, Video: 3.7). In item-wise analysis, AR content shows statistically significant differences in all 12 questionnaire items according to Wilcoxon signed-rank test results ($p<0.05$). Particularly high scores are recorded in Q3 (enhanced original painting understanding: 4.9), Q4 (concrete cognition: 4.8), and Q6 (Joseon Dynasty cultural understanding: 4.6).

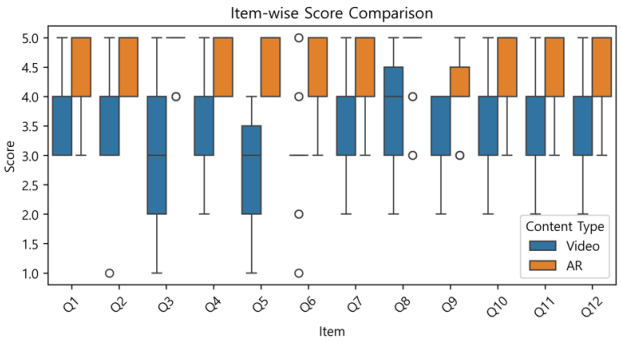



Figure 6. Item-wise Score Comparison.

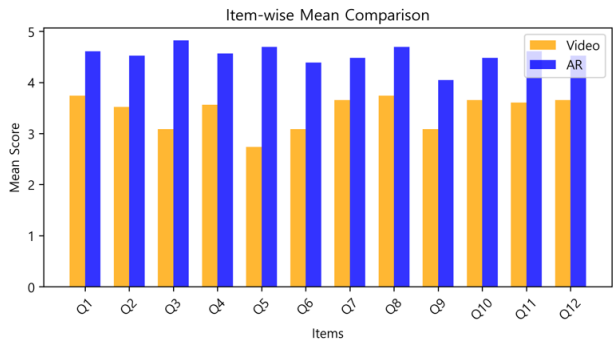



Figure 7. Item-wise mean comparison

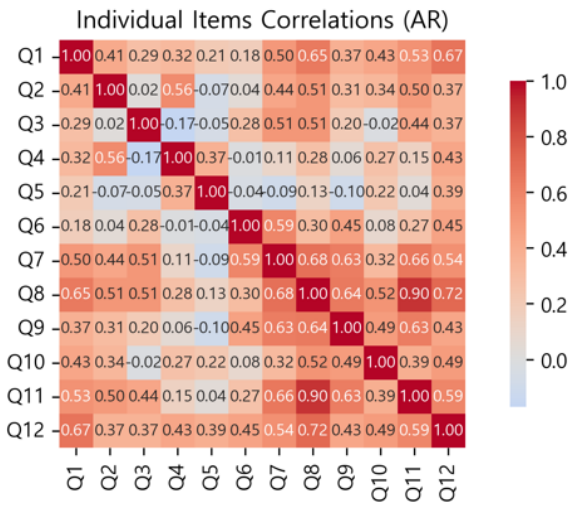



Figure 8. Individual items correlations.

Through correlation analysis between AR content questionnaire items as shown in Figure 8, learning mechanisms conforming to

design intentions are confirmed. In spatial-temporal connection learning pathways, mediating effects in the pathway from Q5 (geographical connection) → Q4 (concrete cognition) → Q2 (value recognition) are confirmed (r=0.37, r=0.56). Interestingly, a weak negative correlation is observed between Q5 and Q2 (-0.07). This suggests that while geographical connections mediate value recognition, excessive contextual information may simultaneously produce negative effects on direct appreciation experiences. In culture-immersion connections, strong correlation between Q6 (cultural understanding) and Q7 (concentration) (r=0.59) demonstrates that deep cultural learning and content immersion constitute mutually reinforcing relationships.

While AR content scored higher than the video content in all immersion items, a negative correlation was observed between Q5 (geographical context) and immersion. This suggests that while interactive characteristics of AR technology enhance overall immersion, cognitive load from contextual information processing may simultaneously limit certain immersion elements. These results indicate the necessity of exploring balance points between contextual learning and intuitive experiences.

The separation phenomenon between cultural understanding and artwork understanding is also noteworthy. Q6 (*Joseon* Dynasty cultural understanding) shows strong correlations with immersion elements while showing relatively weak correlation with Q1 (artwork understanding). This suggests that interactive learning through AR content promotes deep understanding of individual elements but may be relatively limited in integrated understanding of entire artworks. Users effectively learn roles of individual figures and objects, but this partial information does not naturally integrate into overall artwork contexts.

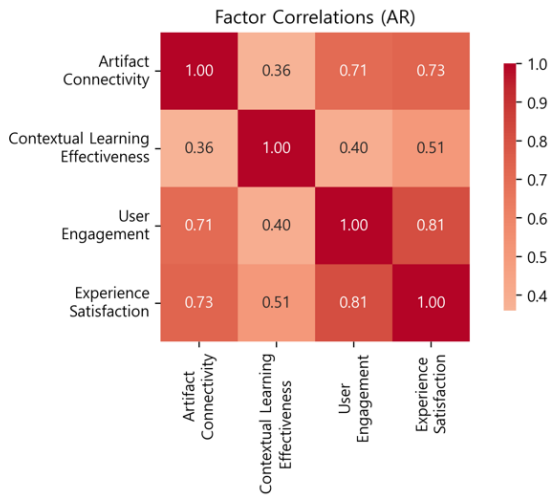



Figure 9. Factor Correlations.

As shown in Figure 9, factor correlation analysis confirms strong associations between Artifact Connectivity and User Engagement (r=0.71), demonstrating that higher connectivity with original artifacts increases user immersion. Additionally, high correlation between Contextual Learning Effectiveness and Experience Satisfaction (r=0.51) is observed, suggesting that efficacy through learning leads to overall user satisfaction.

Participants' qualitative feedback supports these quantitative results. Positive evaluations stating "the connectivity transcending time and space was impressive through cross-comparison of locations included in painting narratives with current positions using maps," "while it was difficult to experience actual geographical distances through painting descriptions alone, understanding was enhanced by showing contemporary maps together," and "contexts of scenes could be concretely recognized through dialogue of characters in AR content" specifically demonstrate effects of spatial narrative connections and contextual learning.

Regarding improvements, feedback included "in route experience sections, character movement was too free despite designated destinations, causing previously viewed popup windows to reopen or missing necessary content during exploration," "if surrounding environments in AR content were consistent with painting environments, visual connectivity between content and paintings would increase," "other sections provided as explanations in painting information parts, such as *Gyoryonggi*, should also be provided as AR content," and "when viewing actual maps, displaying overall processional routes in addition to regional markers would be beneficial," indicating necessity for exploring balance points between learning effectiveness and user autonomy, as well as content expansion and usability improvements.

Limitations of this experiment include: first, evaluation is conducted in controlled laboratory environments rather than actual museums, potentially underestimating spatial immersion of projection mapping content. Second, limited sample sizes of approximately 20 participants restrict result generalization, with non-parametric testing is required due to non-normal distribution in some questionnaire items. Third, AR content shows ceiling effects with multiple questionnaire items scoring above 4.5 points, limiting discriminatory power. Finally, as content targeting a single artwork, applicability to other types of painting heritage requires additional verification.

Nevertheless, this paper demonstrates successful achievement of design goals providing original artifact-centered experiences and systematic contextual learning simultaneously. Particularly, connections between past and present through spatial narratives and multilayered learning structures are confirmed to function effectively, providing important implications regarding balance points between contextual information and immersive experiences that should be considered in cultural heritage content design utilizing AR technology.

## 5. Conclusion and Future Works

This paper presented artifact-centered augmented reality content design methodology targeting the *Hwaneohaengneoldo*, a Joseon Dynasty painting heritage, and verified its effectiveness. Core contributions of the paper are as follows. First, artifact-centered AR design methodology was presented with significant results, as demonstrated through experiments. Through strong correlations between artifact connectivity and user immersion, it was discovered that authentic appreciation experiences of original artifacts influence user participation and immersion. Second, effective learning mechanisms are confirmed by applying contextual learning theory to actual AR content design. The spatial-temporal connection learning pathway (Q5→Q4→Q2) connecting present visitors' geographical contexts with past historical narratives is statistically validated, demonstrating possibilities for creating learning environments enabling perception of abstract historical information as concrete events. Third, important dilemmas to be considered in AR content design are discovered. Negative correlations between geographical contextual information provision and immersive experiences suggest necessity for exploring balance

points between contextual learning and intuitive experiences. Additionally, separation phenomena between individual element learning and comprehensive artwork understanding are confirmed. Weak correlation between Q6 (cultural understanding) and Q1 (artwork understanding) demonstrates necessity for strengthening connectivity between information provision and contextual integration.

Future work will involve expanding the sample size and establishing suitable experimental environments, such as real museum settings, to overcome the limitations identified in the current evaluation. Additionally, based on participant feedback, usability improvements, AR marker area expansion and content diversification, and exploration of methods strengthening connections between individual learning and integrated understanding are required. Particularly, research on methods enhancing connectivity between user learning and immersion is needed to develop optimized AR design methodology enabling contextual learning and immersive experiences to achieve synergy.

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