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Event-Based Engagement and Post-Event Visitor Activity in a Roblox-Based Metaverse Art Museum

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Abstract: Metaverse-based museums have been increasingly adopted by cultural institutions to expand access to cultural heritage and provide interactive digital experiences. However, sustaining visitor engagement after the initial launch remains a major operational challenge. This study examines event-based engagement and post-event visitor activity in the Virtual Moonshin Art Museum, a Roblox-based metaverse art museum. A 13-month longitudinal operational dataset was analyzed, including monthly visitor counts, access device types, age distributions, and average visit duration. The intervention combined quiz and exploration missions within Roblox with an Instagram-based certification event and tangible rewards. The average monthly number of visitors increased from 20.1 during the pre-event period to 312.0 during the event period. However, visitor activity declined sharply after the event ended, indicating that the substantial short-term increase observed during the event did not continue into the post-event period. Mobile phone access was highest during the event period (82.5%), and visitors aged 18 or older constituted the largest age group across all three periods, reaching 83.8% during the event period. These findings suggest that recurring events, continuous content updates, repeatable missions, and community-based participation may be relevant operational strategies for future investigation. This study provides empirical evidence and practical implications for public cultural institutions seeking to operate metaverse-based cultural spaces under limited human and financial resources.

Keywords: Cultural heritage; Gamification; Metaverse museum; Roblox; Visitor activity

1. Introduction

Metaverse-based museums have been increasingly adopted by cultural institutions to provide access to cultural heritage and interactive digital experiences without geographical constraints. However, many virtual museums experience a rapid decline in visitor activity after their initial release, particularly when continuous content updates and operational resources are limited. This challenge is especially important for public cultural institutions, which often lack the personnel and budgets required to maintain visitor interest over time. The Roblox-based Virtual Moonshin Art Museum, previously developed and reported by Kang et al. [1], was publicly released as an online cultural space, but its visitor numbers gradually decreased after the initial launch. An Instagram-based certification event combined with quiz and exploration missions was therefore introduced to increase participation. Although such events may attract visitors in the short term, it remains unclear whether increased visitor activity continues after the event ends and what operational strategies are required to sustain engagement.

The purpose of this study is to examine changes in visitor activity and usage

patterns associated with an event-based intervention in a Roblox art museum. Based on this objective, the following research questions were formulated:

RQ1. How did monthly visitor counts change across the pre-event, event, and post-event periods?

RQ2. How did average visit duration change across the pre-event, event, and post-event periods?

RQ3. How did access device types and age distributions change across the pre-event, event, and post-event periods?

RQ4. To what extent did aggregate visitor activity continue after the event ended?

These research questions were examined using a descriptive longitudinal case-study approach based on 13 months of aggregate operational data from the Virtual Moonshin Art Museum. Because the platform data did not allow individual users' repeat visits to be tracked, post-event visitor activity was assessed at the aggregate level rather than as individual-level revisit behavior. Unlike the previous study, which focused on the collaborative development process and educational outcomes of the Virtual Moonshin Art Museum, the present study examines the museum after its public release using longitudinal operational data. The novelty of this study lies in analyzing changes in visitor activity and usage patterns before, during, and after an event-based intervention over 13 months of actual public operation. In this way, the study extends the previous development-oriented research by providing operational evidence on the distinction between short-term visitor acquisition and continued post-event visitor activity. The findings are intended to provide practical guidance for public cultural institutions seeking cost-effective ways to operate metaverse-based cultural spaces.

2. Related works

Virtual museums have evolved from digital reproductions of physical exhibition spaces into interactive cultural service platforms. Early approaches mainly focused on online exhibitions, virtual tours, and three-dimensional representations of museum collections, thereby improving accessibility without temporal or geographical constraints. More recent studies have emphasized that virtual museums should provide meaningful user experiences rather than merely reproduce physical spaces. Technologies such as artificial intelligence, extended reality, the Internet of Things, and cloud computing can support exhibition design, accessibility, educational effectiveness, and visitor data analysis [2]. Intuitive navigation, interactive content, and contextual interpretation are also important for improving visitors' understanding and satisfaction [3]. However, virtual tours centered on one-way information delivery may have limitations in sustaining visitor engagement over time [4].

XR and metaverse technologies further extend virtual museum experiences through immersive storytelling, spatial interaction, and shared participation [5,6]. Metaverse platforms combine avatar-based navigation, multi-user access, real-time communication, and game-like elements, enabling visitors to actively explore and interact with cultural content [7,8]. Deng et al. also showed that human-computer interaction, social interaction, entertainment, and hedonic experience can influence visitor engagement in virtual museums [9]. Roblox is particularly relevant in this context because it integrates a user-friendly development environment with social and gamified features. Kang et al. developed the Virtual Moonshin Art Museum through a collaborative Roblox Studio program and demonstrated its educational value for understanding cultural spaces and creating metaverse content [1]. However, their study focused on the development process and learning outcomes rather than the subsequent public operation of the museum.

Gamification has been widely used to encourage active participation in virtual museums and cultural heritage environments. Missions, quizzes, exploration tasks, rewards, and cooperative activities can transform visitors from passive viewers into active participants. Previous studies have shown that game elements in immersive exhibitions can improve motivation, interaction, and understanding of cultural content [10,11]. A comparative study involving Roblox and Minecraft has also highlighted the value of accessible interfaces and social functions for cultural heritage learning [12]. In addition, gamified tourism and metaverse experiences may support educational participation and increase younger users' willingness to participate in cultural heritage communication [13,14]. These findings indicate that gamification can strengthen short-term engagement, although many studies have relied on controlled experiments, surveys, or behavioral intentions rather than long-term operational data.

Social media provides another important channel for promoting museum activities and connecting virtual experiences with broader audiences. Museums' online presence and social media engagement can influence visitors' decisions and participation [15], while social media marketing may strengthen social presence, support, and flow experiences [16]. Events can also create a temporary focal point that attracts new visitors, particularly younger audiences [17]. In a metaverse museum, an event may connect internal activities, such as completing missions, with external actions, such as posting certification images or hashtags. Such strategies can combine content updates, public promotion, social sharing, and tangible incentives. However, because these components are implemented together, operational data generally show the outcomes associated with the combined intervention rather than the independent effect of each element.

From a conceptual perspective, the event-based intervention can be understood as a participation mechanism that combines motivational and promotional factors. Gamified missions and rewards may encourage active exploration and task completion [10,11], while social media exposure can increase awareness and support participation decisions [15,16]. A time-limited event may further concentrate visitor attention and encourage participation within a specific period [17]. Therefore, visitor participation in this study is interpreted as an outcome associated with the combined influence of gamified activities, promotional exposure, and cross-platform social interaction rather than any single component.

Despite the potential of immersive interaction, gamification, and social media linkage, sustaining visitor activity remains a major challenge for metaverse-based cultural spaces. Visitor interest may decline after an initial release or promotional event when new content and interaction opportunities are not continuously provided. Long-term metaverse operation therefore requires ongoing value creation, regular content updates, and data-driven decision-making [18]. Cultural heritage applications similarly require continuous management, institutional support, and operational planning beyond their initial development [19]. These requirements are particularly challenging for public cultural institutions, which are expected to improve cultural accessibility and promote local resources while operating with limited budgets and technical personnel. Metaverse services can contribute to public value, but their societal impact depends on how they are maintained and operated over time [20].

Previous studies have provided important insights into virtual museum design, immersive experience, gamification, and social media engagement. Nevertheless, relatively few studies have examined changes in actual visitor activity during the long-term public operation of a metaverse museum. In particular, limited evidence is available on how visitor activity changes before, during, and after an event-based intervention. To address this gap, the present

study analyzes 13 months of operational data from the Roblox-based Virtual Moonshin Art Museum. By comparing visitor numbers and usage patterns across the pre-event, event, and post-event periods, this study examines both short-term visitor inflow and the continuation of aggregate visitor activity after the event.

3. Virtual museum and event-based intervention design

The Virtual Moonshin Art Museum was developed through the Virtual Art Museum Education Program (VAMEP) proposed by Kang et al. [1]. The program involved 15 undergraduate and graduate students from Changwon National University and was conducted over a four-week period. Before developing the virtual museum, the participants attended workshops and visited the physical Moonshin Art Museum to understand its spatial structure, the artistic world of Moonshin, and the characteristics of his major works.

The participants were organized into four teams responsible for architecture, artworks, avatars, and interactive content. Using Roblox Studio, the architecture team reconstructed the spatial structure of the museum, while the artwork team created and placed digital representations of Moonshin's works. The avatar and content teams developed user characters and interactive elements for exploring the virtual exhibition. **Figure 1** presents the development process and the original version of the Roblox-based Virtual Moonshin Art Museum before the event-based intervention. The previous study demonstrated the educational value of collaboratively reconstructing a cultural space using Roblox; however, it did not examine the subsequent public operation of the completed museum [1].



Figure 1. Development process and original version of the Roblox-based Virtual Moonshin Art Museum before the event-based intervention.

The Virtual Moonshin Art Museum was publicly released on Roblox in January 2022. Visitors could access the museum using a Roblox account, navigate the exhibition space through an avatar, and view artworks and related information. The virtual environment allowed users to experience the architectural and artistic characteristics of the Moonshin Art Museum without geographical or temporal constraints.

Visitor activity, however, declined after the initial release. The museum recorded 57 visitors in January 2022, but the number decreased to 21 in February and reached 4 in April. The original version primarily supported spatial exploration and the viewing of artwork information, providing limited motivation for repeated participation. In addition, the small number of concurrent

visitors restricted the use of Roblox's social and multi-user features. These operational challenges motivated the development of an event-based intervention that combined new in-platform activities with external social media participation.

For the event-based intervention, the original virtual museum was updated with quiz and exploration missions. Whereas the initial version mainly provided avatar-based navigation and artwork information, the updated version required visitors to actively interact with the exhibition content and complete specific tasks.

The quiz missions asked visitors to answer questions about Moonshin and his artworks. To obtain the correct answers, users were encouraged to examine descriptions and information available throughout the virtual museum. The exploration missions required users to move through the exhibition space and locate designated artworks or information. These missions were intended to connect spatial exploration with the interpretation of cultural content, rather than allowing visitors to complete the event through passive viewing alone. **Figure 2** illustrates the quiz and exploration missions implemented in the Virtual Moonshin Art Museum.



Figure 2. Quiz and exploration missions in the Virtual Moonshin Art Museum.

After completing the required missions, visitors received a mission completion screen, as shown in **Figure 3**. The event required participants to complete all designated quiz and exploration missions before the mission completion screen was displayed. The screen served as evidence of participation and could be captured and uploaded to Instagram. This mechanism connected activities performed within Roblox to the external social media certification process. The event-based update therefore transformed the original exhibition-centered environment into a participation-oriented experience involving exploration, learning, task completion, and social sharing. The main components of the event-based content update are summarized in **Table 1**.



Figure 3. Mission completion screen for social media certification.

Table 1. Components of the event-based content update.

Component	Description	Role in event participation
Quiz mission	Answering questions about Moonshin and his artworks	Encouraging visitors to examine exhibition information
Exploration mission	Locating specific artworks or information within the virtual museum	Promoting spatial exploration and artwork understanding
Mission completion screen	Displaying a certification screen after all required missions were completed	Providing evidence for social media participation
Instagram linkage	Uploading the completion screen to a personal Instagram account	Connecting the Roblox experience with an external social platform

Together, these components formed a sequential participation structure. Visitors first explored the virtual museum, interacted with exhibition content, completed the missions, and then shared the result through Instagram. The intervention was therefore designed as an integrated experience rather than as a separate promotional campaign added to the existing museum. Viewed as a participation pathway, the intervention linked external promotional exposure to entry into Roblox, completion of quiz and exploration missions, certification and social sharing through Instagram, and the opportunity to receive a tangible reward.

The “Social Media Certification Event for Visiting the Roblox-based Moonshin Art Museum Commemorating the 100th Anniversary of Moonshin’s Birth” was jointly organized by Changwon City Hall and the official account for the 100th anniversary of Moonshin’s birth. The event was announced on the Changwon City Hall website and Instagram on August 3, 2022, and was conducted from August 16 to September 30, 2022. The winners were announced on October 10, 2022.

Participation consisted of six steps. Visitors first downloaded the Roblox application and searched for the “Moonshin 100th Anniversary Event.” They then entered the Virtual Moonshin Art Museum, completed the quiz and exploration missions, and captured the mission completion screen. The captured image was uploaded to the participant’s Instagram account with the required hashtags and account tags. Participants were also required to follow the official Moonshin 100th anniversary account and leave a comment on the event announcement post containing their Roblox ID and confirmation of participation.

The event used both first-come-first-served and lottery-based rewards. The first 100 participants received a Baskin-Robbins gift certificate valued at KRW 5,000, and an additional 100 participants were selected through a lottery to receive the same reward. This structure was intended to encourage rapid initial participation while preserving an incentive for users who joined later in the event period. The Instagram event post recorded 98 likes and 180 comments.

A key characteristic of the intervention was the connection between internal and external activities. Participants could not complete the event solely by

responding to an Instagram post; they were required to enter the virtual museum, explore its content, complete the missions, and generate a certification image. The intervention therefore combined four operational components: gamified content updates within Roblox, public promotion, social media sharing, and tangible rewards.

The event also functioned as a public cultural initiative intended to promote Moonshin, the Moonshin Art Museum, and local cultural heritage. Accordingly, the intervention was evaluated as a combined operational strategy rather than as a test of any single component. The following section analyzes changes in visitor activity before, during, and after the intervention using operational data collected from the Virtual Moonshin Art Museum.

4. Methodology

Operational data from the Roblox-based Virtual Moonshin Art Museum were collected over a 13-month period, from January 2022 to January 2023. The dataset included monthly visitor counts, access device types, age distributions, and average visit durations. Operational data were obtained from the Roblox Analytics Dashboard. Monthly visitor counts were based on the Active Users metric reported by the platform, and average visit duration was based on the monthly average duration reported by the Roblox Analytics Dashboard. The values reported in the dashboard were reviewed and manually organized into tables for analysis. No missing monthly data were identified during the observation period.

In this study, monthly visitor counts were used as an indicator of visitor acquisition or traffic, while average visit duration was treated as a supplementary and indirect indicator of visitor engagement. Access device types and age distributions were used to describe visitor profiles rather than engagement. Post-event visitor activity was assessed based on changes in aggregate visitor counts after the event and was not interpreted as individual-level revisit behavior.

The analysis period was divided into three phases. The pre-event period covered January to July 2022, during which the virtual museum was publicly accessible without the intervention. The event period covered August and September 2022, during which the social media certification event and the quiz and exploration missions were implemented. The post-event period covered October 2022 to January 2023 and was used to examine whether aggregate visitor activity continued after the event ended. Because the available platform data were aggregated by month, August 2022 was classified as part of the event period. Although the in-platform event officially began on August 16, public announcement and promotion had already started on August 3 through the Changwon City Hall website and Instagram. The three analysis phases and their corresponding operational conditions are summarized in **Table 2**.

Table 2. Analysis period and data categories.

Category	Period	Description
Pre-event period	Jan. 2022–Jul. 2022	General operation before the social media certification event
Event period	Aug. 2022–Sep. 2022	Social media certification event and Roblox mission-based content update
Post-event period	Oct. 2022–Jan. 2023	Operation after the official event ended

The analysis was descriptive because the dataset consisted of aggregate monthly operational indicators rather than individual-level behavioral records. Accordingly, the analysis focused on changes in visitor counts, proportions, and monthly average visit durations across the observation period. The study did not attempt to isolate the independent causal effects of the Roblox content

update, social media promotion, certification process, public promotion, or tangible rewards. Only aggregate operational data were used, and individual-level information or personally identifiable information was not available to the authors. Because the study analyzed only aggregate operational data and did not involve the collection of identifiable individual-level information, it was considered outside the scope of institutional review for human-subject research.

5. Results and discussion

The findings are discussed around four main operational patterns: event-driven visitor acquisition, post-event decline, mobile and cross-platform participation, and audience characteristics. The visitor data show a substantial increase in activity during the event period. As presented in **Table 3**, the Virtual Moonshin Art Museum recorded 141 visitors during the seven-month pre-event period, with a monthly average of 20.1. During the two-month event period, the total visitor count increased to 624, corresponding to a monthly average of 312.0. Thus, the average monthly visitor count during the event period was approximately 15.5 times higher than that observed before the event.

Table 3. Comparison of visitor numbers by operation period.

Category	Period	Total visitors	Monthly average	Highest	Lowest
Pre-event period	Jan. 2022 –Jul. 2022	141	20.1	57	4
Event period	Aug. 2022 –Sep. 2022	624	312.0	394	230
Post-event period	Oct. 2022 –Jan. 2023	55	13.8	20	7
Total	Jan. 2022 –Jan. 2023	820	63.1	394	4

The monthly visitor counts are presented in **Table 4**, while the corresponding time-series pattern is illustrated in **Figure 4**. The museum recorded 57 visitors in January 2022, when it was first released, but visitor activity subsequently declined. Only four visitors were recorded in April, and monthly counts remained between 10 and 14 from May to July.

Table 4. Monthly visitor numbers.

Month	Visitors	Note
Jan. 2022	57	Initial public release
Feb. 2022	21	
Mar. 2022	24	
Apr. 2022	4	
May 2022	11	Lowest point before event
Jun. 2022	14	
Jul. 2022	10	
Aug. 2022	394	Before event announcement
Sep. 2022	230	Event started; highest point
Oct. 2022	11	Event in progress
Nov. 2022	17	Sharp decline after event
Dec. 2022	20	
Jan. 2023	7	

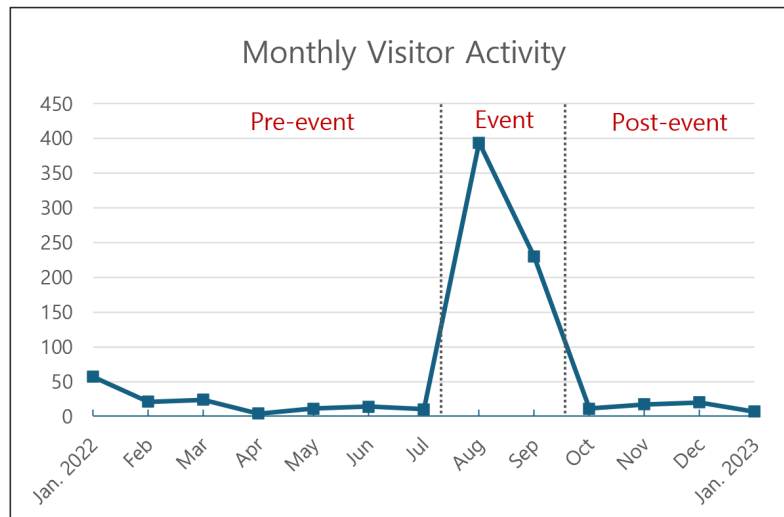


Figure 4. Monthly visitor activity from January 2022 to January 2023.

As shown in **Figure 4**, visitor activity increased sharply during the event period, reaching 394 visitors in August and 230 in September. After the event ended, the monthly count decreased to 11 in October and remained relatively low through January 2023. This pattern indicates that the combined intervention was associated with a strong short-term increase in visitor inflow, but that the increase did not continue after the event ended.

The magnitude of this increase should also be interpreted in light of the broader context of the event. The campaign commemorated the 100th anniversary of Moonshin’s birth and was promoted by Changwon City Hall, which may have increased public awareness and visitor inflow independently of the in-platform missions, social media certification, or tangible rewards. Because these contextual influences occurred concurrently with the event-based intervention, the individual contribution of each component cannot be determined from the available operational data. Within this limitation, the observed short-term increase is consistent with the conceptual perspective that visitor participation may be supported by the combined influence of gamified activities, promotional exposure, and cross-platform social interaction.

However, the increase did not continue after the event ended. The visitor count decreased from 230 in September to 11 in October, representing a decline of approximately 95.2%. Visitor activity remained low thereafter, with 17 visitors in November, 20 in December, and seven in January 2023. The post-event monthly average of 13.8 was lower than the pre-event average of 20.1.

These results distinguish short-term visitor acquisition from sustained visitor activity. Visitor activity increased substantially while the intervention was active, but the post-event decline indicates that the increased inflow did not translate into sustained aggregate participation. Because individual users could not be tracked across visits, this result should not be interpreted as direct evidence of individual-level revisit behavior.

One possible explanation for the post-event decline is that the intervention was structured primarily around a time-limited mission and reward experience. After visitors completed the required missions and certification process, the existing content provided limited additional incentives for repeated participation. In addition, the event did not include persistent community activities or recurring social interactions after the campaign ended. These factors may have limited continued visitor activity, although the available aggregate data do not allow their individual effects to be verified.

The distribution of access devices varied across the three analysis periods.

As shown in **Table 5**, mobile phone access accounted for 47.5% of visitors during the pre-event period and increased to 82.5% during the event period. Although the proportion decreased to 61.8% during the post-event period, mobile phones remained the most frequently used access device.

Table 5. Device distribution across the three analysis periods.

Device	Pre-event, n(%)	Event, n(%)	Post-event, n(%)
Mobile phone	67 (47.5%)	515 (82.5%)	34 (61.8%)
Computer	50 (35.5%)	87 (13.9%)	8 (14.5%)
Tablet	24 (17.0%)	22 (3.5%)	13 (23.6%)
Total	141 (100.0%)	624 (100.0%)	55 (100.0%)

The increased proportion of mobile access may be associated with the cross-platform structure of the intervention. Visitors encountered the event announcement through Instagram, accessed Roblox, completed the missions, captured the certification screen, and uploaded the image to Instagram. Because these activities could be completed within a mobile-centered participation flow, the connection between Instagram and Roblox may have reduced barriers to participation. From an operational perspective, this pattern suggests that mobile-friendly cross-platform design may be important for public metaverse cultural services, particularly when participation begins through social media and continues within a mobile-accessible virtual environment. However, the present data do not establish that a mobile-first strategy caused the increase in participation, and further research is needed to examine how device accessibility influences participation behavior.

Changes were also observed in the age distribution across the three analysis periods. As shown in **Table 6**, visitors aged 18 or older accounted for 73.0% of visitors during the pre-event period, 83.8% during the event period, and 74.5% during the post-event period. Adults therefore constituted the largest visitor group throughout the observation period, with the highest proportion occurring during the event period.

Although Roblox is commonly associated with younger users, adults constituted the largest visitor group throughout all three analysis periods. The particularly high proportion of adults during the event period may reflect the museum and cultural-heritage context of the experience, as well as the public promotion and Instagram-based participation process. This finding suggests that Roblox-based cultural heritage applications may reach audiences beyond children and adolescents, although the available aggregate data do not allow these influences to be examined separately.

Table 6. Age distribution across the three analysis periods.

Age group	Pre-event, n(%)	Event, n(%)	Post-event, n(%)
18 or older	103 (73.0%)	523 (83.8%)	41 (74.5%)
6 or younger	3 (2.1%)	25 (4.0%)	6 (10.9%)
7–8	6 (4.3%)	13 (2.1%)	2 (3.6%)
9–10	5 (3.5%)	23 (3.7%)	1 (1.8%)
11–12	5 (3.5%)	10 (1.6%)	0 (0.0%)
13–15	17 (12.1%)	17 (2.7%)	2 (3.6%)
16–17	2 (1.4%)	13 (2.1%)	3 (5.5%)

Continued table:

Age group	Pre-event, n(%)	Event, n(%)	Post-event, n(%)
Total	141 (100.0%)	624 (100.0%)	55 (100.0%)

Beyond these patterns in visitor acquisition and visitor profiles, average visit duration was examined as a supplementary and indirect indicator of visitor engagement. As shown in **Table 7**, the mean monthly average visit duration was 7.26 minutes during the pre-event period and 7.58 minutes during the event period, representing only a small difference between the two periods. Monthly changes in average visit duration are presented in **Table 8** and visualized in **Figure 5**. As shown in **Figure 5**, the highest monthly value during the entire observation period was recorded before the event, in June 2022, at 12.52 minutes. Therefore, the small difference between the pre-event and event periods should not be interpreted as evidence that the event-based intervention increased visitor engagement. During the post-event period, the mean monthly average visit duration decreased to 3.45 minutes, with the lowest monthly value of 1.39 minutes recorded in January 2023. This pattern indicates that visitors spent less time per visit during the post-event period; however, because the analysis was descriptive, changes in average visit duration alone cannot establish changes in visitor engagement.

Table 7. Mean monthly average visit duration by analysis phase.

Category	Period	Average visit duration
Pre-event period	Jan. 2022–Jul. 2022	7.26 min
Event period	Aug. 2022–Sep. 2022	7.58 min
Post-event period	Oct. 2022–Jan. 2023	3.45 min

Table 8. Monthly average visit duration.

Month	Average visit duration	Note
Jan. 2022	6.24 min	
Feb. 2022	3.46 min	
Mar. 2022	3.43 min	
Apr. 2022	8.04 min	
May 2022	9.68 min	
Jun. 2022	12.52 min	Highest point
Jul. 2022	7.46 min	
Aug. 2022	6.86 min	Event started
Sep. 2022	8.29 min	Event in progress
Oct. 2022	4.81 min	Event ended
Nov. 2022	4.12 min	
Dec. 2022	3.49 min	
Jan. 2023	1.39 min	Lowest point

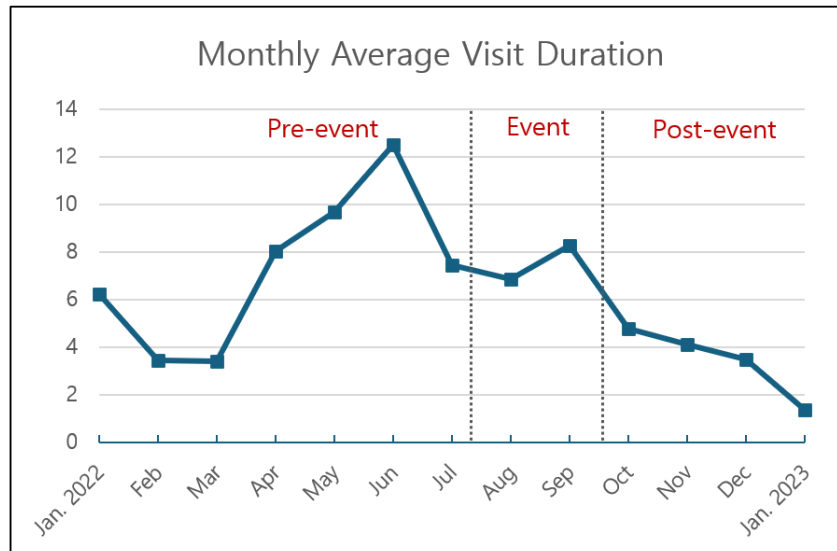


Figure 5. Monthly average visit duration from January 2022 to January 2023.

After the event, both visitor counts and average visit duration declined. However, average visit duration should be interpreted cautiously because longer visits do not necessarily indicate greater satisfaction, learning, or meaningful interaction, and changes in this metric alone cannot establish changes in visitor engagement. In addition, the platform data did not provide information about the specific activities performed by individual visitors.

Taken together, these findings highlight an important distinction between short-term visitor acquisition and sustained visitor activity. Although the event period was associated with a substantial increase in monthly visitors, the post-event monthly average decreased to 13.8 visitors, below the pre-event average of 20.1 visitors. This pattern suggests that attracting visitors during a time-limited event does not necessarily translate into continued activity after the event ends. While previous studies have shown that gamification and social media engagement can support visitor participation [10,15], other studies have emphasized the importance of continued value creation, content updates, and operational support for the long-term management of metaverse and digital cultural spaces [18,19]. Accordingly, recurring events, updated content, and community-based participation structures should be considered as potential operational strategies for future investigation rather than as outcomes directly demonstrated by the present study.

6. Conclusion

This study examined event-based engagement and continued visitor activity in the Roblox-based Virtual Moonshin Art Museum using 13 months of operational data. The intervention combined quiz and exploration missions within Roblox with an Instagram-based certification event and tangible participation rewards. Visitor activity was compared across the pre-event, event, and post-event periods using monthly visitor counts, access device types, age distributions, and average visit durations.

The findings showed that the intervention was associated with a substantial short-term increase in visitor inflow. The average monthly visitor count increased from 20.1 during the pre-event period to 312.0 during the event period. However, visitor activity declined sharply after the event ended and remained below the pre-event monthly average during the post-event period. Average visit duration also decreased after the event. These results show that visitor activity increased substantially while the intervention was active, but that the increase did not continue after the event ended. Because individual users could not be tracked

across repeated visits, this finding should be interpreted as evidence of post-event changes in overall visitor activity rather than individual-level revisit behavior.

The device and age distributions provide additional practical insights. Mobile phone access accounted for 47.5% of visitors during the pre-event period, 82.5% during the event period, and 61.8% during the post-event period. Visitors aged 18 or older accounted for 73.0%, 83.8%, and 74.5% across the same three periods, respectively. These patterns suggest that mobile accessibility and adult participation are relevant considerations for metaverse-based cultural services, although the present data do not establish the independent effects of cross-platform design, promotional channels, or cultural context. These findings suggest that metaverse museums should be designed not only around the technical characteristics of the virtual platform but also around the external communication channels and devices through which users enter and participate in the experience.

This study makes two main contributions. First, it provides longitudinal evidence from the actual public operation of a Roblox-based metaverse museum. Previous research has often examined virtual museums through short-term experiments, surveys, or behavioral intention measures, whereas this study analyzes changes that occurred during 13 months of real-world operation. Second, it distinguishes between short-term visitor acquisition and sustained visitor activity. The observed increase occurred during an intervention that combined gamified missions, social media linkage, public promotion, and incentives, although the contribution of each component cannot be determined independently. The post-event decline further suggests that continued visitor activity requires an ongoing operational structure rather than reliance on a single event. Accordingly, recurring events, periodic exhibition updates, repeatable or progressive missions, community interaction, and data-driven visitor monitoring may be considered as potential operational strategies for future investigation rather than as outcomes directly demonstrated by the present study.

Several limitations should be considered. First, the study examined a single Roblox-based virtual art museum, and the findings may not be directly generalizable to other museums, platforms, or cultural contexts. The specific magnitude of the observed visitor increase should therefore be interpreted as case-specific and should not be generalized directly to other metaverse museums or cultural events. However, broader operational patterns identified in this case—including event-driven visitor acquisition, cross-platform participation, and the difficulty of maintaining visitor activity after time-limited incentives end—may provide transferable insights for other metaverse-based cultural services. Second, the dataset consisted of aggregated operational indicators and did not include individual navigation paths, repeat-visit records, satisfaction measures, or qualitative feedback. Third, the intervention simultaneously introduced mission-based content, Instagram promotion, certification requirements, and tangible rewards. Consequently, the analysis cannot determine the independent contribution of each component. In addition, the monthly aggregation of the dataset limited more detailed analysis of visitor activity immediately before and after the event.

Future research should collect individual-level interaction logs and revisit data and conduct surveys and interviews to examine why visitors participate, which activities support meaningful engagement, and how engagement develops over time. Comparative studies involving different event formats, reward structures, cultural themes, and metaverse platforms would also help identify which operational strategies are most effective. The post-event decline observed in this study also suggests a need to explore mechanisms that can support recurring or continuously updated interactions without substantially increasing operational burden. Generative AI and conversational agents may provide an

additional direction for reducing the operational burden of virtual cultural spaces. For example, AI-based systems could support the continuous generation of quizzes, exhibition descriptions, personalized recommendations, and narrative content. Persona-based conversational non-player characters could also provide guidance, storytelling, and social interaction when few human visitors are present. However, the effectiveness of these technologies should be evaluated separately through future user studies and operational experiments.

In conclusion, the sustainable operation of a metaverse museum depends not only on constructing a virtual space but also on maintaining a continuous cycle of content, participation, promotion, and community interaction. The Virtual Moonshin Art Museum case demonstrates that the event-based intervention was associated with substantial short-term visitor inflow, while the rapid post-event decline highlights the need for recurring and resource-conscious operational strategies. These findings provide practical guidance for public cultural institutions seeking to transform metaverse museums from one-time development projects into continuously managed cultural service platforms.

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