

# Effects of Gamification and Immersive Technology on Museum Learning: A User-Centered Empirical Study

<sup>1</sup>Yan Xuning., <sup>2</sup>Zhang Jimin

<sup>1</sup>Faculty of Design and Architecture, University Putra Malaysia, Selangor, Malaysia

<sup>2</sup>The Design School, Taylor's University, Selangor, Malaysia

\*Corresponding Author

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## ABSTRACT

This study investigates the impact of gamification and immersive technologies on museum learning effectiveness from a user-centered perspective. A quantitative survey was conducted with 396 participants from the United Kingdom, China, and other countries. The measurement model included three constructs: immersion, gamification, and perceived learning effectiveness. Reliability and regression analyses were performed to examine predictive relationships. The findings reveal that both immersion and gamification significantly enhance perceived learning effectiveness. Immersive technologies strengthen users' sense of presence and realism, while gamification increases engagement through challenges and rewards. Together, these elements demonstrate a complementary effect in promoting cognitive and motivational aspects of informal learning. This study contributes to the literature by providing empirical evidence for an integrated evaluation approach to gamified immersive museum learning. The results offer practical implications for museum designers seeking to optimize educational impact through balanced experiential and motivational design strategies.

**Keywords:** Gamification ; Immersive Technology ; Museum Learning ; User-Centered Evaluation ; Informal Education

## INTRODUCTION

The research topic involves the expansion of gamification and immersive technology, with a particular focus on the innovation of learning experience. At present, the learning environment of museums, science and technology museums and other museums plays an increasingly prominent role in social education. Museum learning helps foster a sense of identity within the wider community, and also encourages social tolerance among family groups and wider groups. (Madsen and Jensen, 2021) Museum learning develops practical, personal and knowledge-based skills with the potential for lifelong learning outcomes. (Hamilton and Margot, 2020) Museum learning is of great significance in popularizing education in society and improving the quality and well-being of the whole people. Studies have shown that the advantage of museum learning is that it can provide a unique multi-sensory learning environment (Wang, 2020). However, due to the lack of precise and efficient event design and exhibit design, there is less in-depth interaction between visitors and exhibits, and it is difficult to promote the development of their high-level thinking skills.

The main research question of this research is: How gamification and immersive (GI) technology influence the museum learning effects? The aim of this research is to explore the combination, design and application of gamification and immersive technology in museum learning, with a particular focus on exploring the impact of gamification and immersion on learner experience and social education based on user-centered and participatory design concepts.

## LITERATURE REVIEW

### Museum learning

If museum learning intends to obtain the ideal communication effect and effectively attract the audience, it must adapt to the new media environment, enhance the interaction and openness in the learning process, so as to highlight the innovation and difference of the design works (Ilamsyah, Wulandari and Fahreza, 2020). This research constitutes a relatively new field, which has been upgraded from focusing on the single content-oriented communication of museum learning to focusing on the process of user feedback and interaction (Bang, Yang, Oh and Ko, 2017). Compared with the one-way design that tells the user, the user's response to the work and interactive two-way communication seems to have better effect (Yang and Zhang, 2020; Zhongliu and Xin, 2019). So this research use participatory design and user-centric approach to explore how to enhance the user experience. However, a large amount of previous researches concentrating on similar topics have focused on the exhibition curation and interior design of museums, often ignoring the ultimate effect of museum learning. The museum is a place to display visual art works and provide educational, artistic and enjoyable experiences for the audience. An increasing number of learners hope to have a creative and interactive experience during the visit. Gamification is a wonderful strategy to create and share cultural content in a more interactive way. The advantages of gamification are to increase audience participation, increase knowledge absorption and retention, cultivate interest in learning, and make the experience more personalized (Al Fatta, Maksom and Zakaria, 2018). Studies have shown that game-based learning is a meaningful and interesting way to overcome some of the challenges of teaching postgraduate research skills (Abbott, 2019). The way of gamification enhances people's enthusiasm for work with its unique interactivity and participation. Although the concept of gamification is widely used in classroom education and corporate training of all ages, there seems to be relatively few studies on gamification in museum learning. Some scholars have suggested that gamification is a museum that provides visitors with more immersive and fascinating experiences (Lamrani and Abdelwahed, 2020). However, the effect of gamification in museum learning has not been confirmed, and the application of gamification appears to be little-discussed area.

### Gamification and immersive technologies

Immersive technology has unique advantages and values in the education field because of its strong interaction, imagination, participation and gameplay. It is a technology that expands reality or creates new reality by using 360-degree space (Bodzin et al., 2021). Certain types of immersive technologies extend reality by superimposing digital images on the user's environment (Tea et al., 2021). For example, VR completely isolates users from the rest of the world and immerses them in a digital environment to create a new reality (Powell and Sharkey, 2017). Through the integration of virtual information and real environment, it brings users a completely new experience, which has unique advantages and value in the education field. Existing studies have found that augmented reality technology is most suitable for exploratory learning in a venue learning environment. Learners can use the visual simulation method of fusion of virtual and reality to realize the exploration of complex scientific phenomena (Panteleris, Michel and Argyros, 2021). Studies have shown that easy-to-use interface design can promote wider citizen participation (May and Ross, 2018). However, factors such as the way of collaboration in the learning environment of the museums, the presentation of exhibits, and the degree of difficulty all affect the learning effect of learners. In addition, augmented reality technology has shown great potential in gamified learning (Cavarelli, Arya and Teather, 2021). Therefore, integrating immersive technology and game elements into museum learning, and improving the learning effect by optimizing the presentation of information and exhibits, and collaboration has become focusing points of this research.

### New challenges

In addition, due to the impact of COVID-19 pandemic crisis, travel and crowds have been restricted in many areas (Linka et al., 2020). For instance, the American Alliance of Museums conducted a survey of museum directors across the United States in June 2020. One-third of the respondents indicated that their museums are facing the risk of permanent closure in the next 16 months; they were unsure whether the museum can survive after the epidemic (National Survey of COVID-19 Impact on United States Museums, 2020). Digital technology and gamification can help people acquire the museum visiting experience and gain knowledge anytime at home.

Accordingly, during this Global pandemic crisis, a large number of museums have already started shifting to digitalization (Liu and Lan, 2021). For instance, the Sedgwick Museum of Earth Sciences in Cambridge in the UK postponed their exhibition and held the first online exhibition (King et al., 2021). However, there are relatively few research and theoretical foundations in this area, and there are difficulties in the construction and development of museums. In the previous researches, although there are a large number of empirical studies that prove that the development of the times has brought an impact on museum learning, so far, very few studies have focused on how museums can utilize GI technique to improve user experience, in order to better improve the learning effect. The research purpose of this article is to explore the impact of gamification and immersive technology on learner experience and social education based on user-centered and participatory concepts. This research aims to develop strategies to solve this challenging problem: How gamification and immersive technology help museums to improve learning effects? The first potential achievement of this research is to promote museum learning, improve museum learning effects, and benefit society. The key potential researching achievements include contributions to the museum sector, which can be summarized as a further supplement to the discipline, providing reference and suggestions for future development of the discipline, and providing more theoretical foundations and design methods for industry workers.

### Reality Analysis



Figure 1 VR exhibition in the British Museum (Charara, 2015)

The study chose the UK and China as primary case contexts. This is mainly because the UK and China both have a long culture and history. The United Kingdom has advanced technology and world-leading artistic standards and is considered the main case country for this study. With a large population, China has the largest number of museums in the world and the largest number of museum visitors per day. (Zhang and Courty, 2021) For example: The British Museum is one of the largest and most famous museums in the world. (Simpson and The British Museum, 2020) In August 2015, the British Museum and Samsung co-organized the first VR exhibition (Figure 1) (Charara, 2015). This is mainly because it is not easy for children from home and school to be interested in Bronze Age bracelets and ceremonial weapons in British classrooms. The previous researches have significantly benefited museums and educators. This kind of technical and gamified exploration is very suitable for making historical relics more approachable.



Figure 2 The Palace Museum VR Project (fractal-technolog, 2021)

In addition, The Palace Museum of China is one of the three largest palaces in the world and the largest museum of ancient culture and art in China. (Duo and The Palace Museum, 2020) In 2019, The Palace Museum launched the first interactive puzzle game book, which combines offline interaction, online games and APP problem solving to promote people's cultural learning. This project crowdfunded 20.2 million RMB and pre-sold 122,000 copies, which has been loved by many people. (The Forbidden City launches the first interactive puzzle game book history + how to play the game in the Forbidden City-Xinhuanet, no date) The launch of The Palace Museum's VThe Palace Museum can also allow people to look at the exhibition from a different perspective. In order to protect the cultural relics, the only way to look at the palace was to stand outside the palace and look inside. With the help of VR technology, people can truly feel the palace they see sitting on the seat of the emperor. (Figure 2) (www. fractal-technology.com, no date)

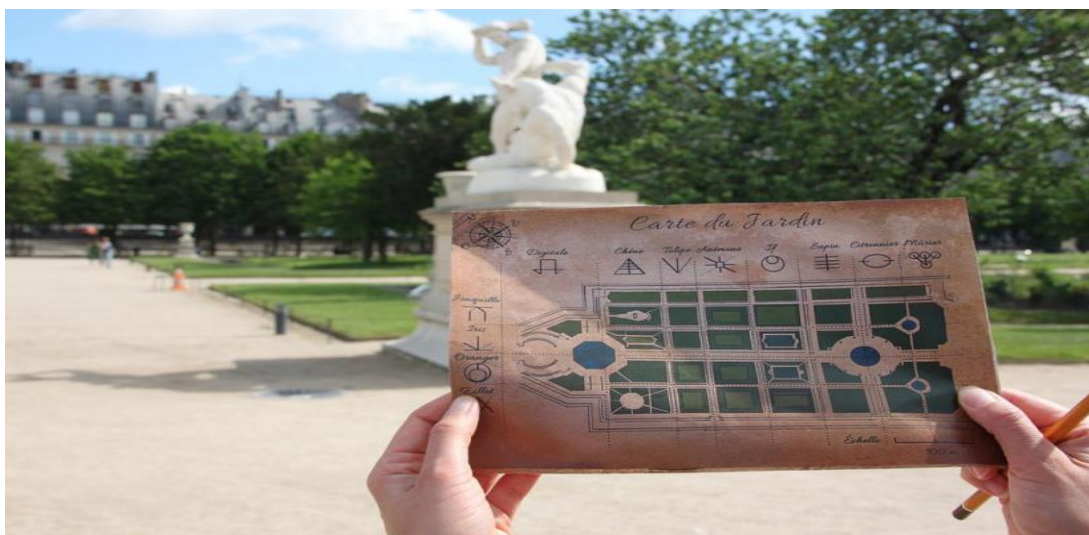


Figure 3. Louvre outdoor gamification learning project (Anne-christine, 2019)

In addition to UK and China-based research, questionnaire survey also involve museums that continue to explore in the field of gamification and immersive technology. By understanding their relatively mature experience and existing problems, provide help for this research. For example: In July 2019, the Louvre (Paris, France) proposed the outdoor adventure game "The Mystery of Tuileries". Visitors can explore the beautifully landscaped gardens of the museum in small groups and try to uncover its secrets. Different levels of difficulty allow tourists of all ages to participate and interact (Figure 3). (Mysteries at the Tuileries: the free and outdoor adventure game, no date) In October 2019, Paris' Louvre launched 'Mona Lisa: Beyond the Glass', which is an experience of exploring Renaissance painting and has five language options. (What are the best examples of virtual reality in

museums?-MuseumNext, 2020) Via questionnaire study, this research explore the advantages and problems of gamification, analyze different immersive technologies used in different works, summarize their advantages and manifestations, and explore applicability of GI technique use in museums learning. Combining the basic framework of gamification of practical cases, analyze the advantages and problems of its design and implementation.

## Terminology

In the context of this research, the term “museum” shall refer to institutions with multiple cultural elements such as art museums, oceanographic museums, exhibition halls, astronomical museums, and historical museums. The museum is a public educational institution that showcases science, art, and culture. (Mujtaba et al., 2018) The construction and development of museums are related to the maturity of residents. (Ćosović and Brkić, 2020) Museum learning refers to informal learning that promotes diverse learning of knowledge in these public institutions through greater flexibility, artistry, and culture. (Tišliar, 2017) The American Association of Museums (now the American Alliance of Museums) formulated the "Principles and Standards of Museum Education" (Hirzy, 1992) to help guide the practice of museum education.

The conceptual framework of this study integrates Flow Theory, Self-Determination Theory, and Experiential Learning Theory to explain how immersive presence and gamified motivation influence perceived learning effectiveness.

## METHODOLOGY

This research used the method of questionnaire survey. (Jabbarova, 2020) (Mills, 2020) Based on the fact that the research question involves interdisciplinary research fields, it is believed that the quantitative research methods is the best choice for comprehensive exploration of the research question. The advantage of quantitative analysis is that the research can focus on a specific aspect. Therefore, in order to improve the objectivity, comprehensiveness and value of the research, this research chooses a combination of quantitative and qualitative research methods. Specifically, the research methods used questionnaire survey. First, this research conducted an in-depth analysis and discussion on the research topic. First, used the literature method to analyze, discuss, and organize the past research background and research cases of museum learning. At the same time, combined with the way of information visualization, this research analyzed and organized the data in the chapter literature, and display the visualization chart (Schultz, Ozarslan and Hotz, 2017).

Therefore, the participants in this study came from the aforementioned countries, totaling 396 people. Among them, 100 were from the UK, 100 from China, and 96 from other countries including France. Gender was not specified. Participants were between 18 and 45 years old. Participants completed the study's questionnaire after visiting the museum.

The measurement instrument was developed based on existing literature on immersive learning, gamification, and informal educational effectiveness. The questionnaire consisted of three main constructs: immersion, gamification, and perceived learning effectiveness. Each construct was measured using three items, resulting in a total of nine measurement items. The immersion dimension assessed participants' sense of presence and realism within the museum experience. This construct included three items: (1) “I feel immersed in the experience,” (2) “The technology enhances realism,” and (3) “I feel present in the virtual environment.” These items were designed to capture the extent to which immersive technology generated psychological presence and environmental authenticity. The gamification dimension evaluated participants' responses to game-related elements embedded in the museum environment. This construct included three items: (1) “I enjoy challenges,” (2) “Rewards motivate me,” and (3) “Game elements increase engagement.” These items measured motivational and participatory aspects associated with gamified design features. The learning effectiveness dimension examined participants' perceived educational outcomes following the museum experience. This construct consisted of three items: (1) “I gained new knowledge,” (2) “I can recall information,” and (3) “The experience improved my understanding.” These items were intended to assess self-reported cognitive gains and comprehension improvements. All items were measured using a five-point Likert scale ranging from 1 (strongly

disagree) to 5 (strongly agree). Higher scores indicated stronger agreement with each statement and more positive evaluations of the museum learning experience.

## RESULTS AND DISCUSSION

### Reliability and internal consistency

Cronbach's alpha coefficients were calculated to assess the internal consistency of the measurement instrument. The results demonstrated satisfactory reliability across all three constructs. The immersion dimension achieved a Cronbach's alpha of 0.87, indicating strong consistency among items measuring presence and realism. The gamification dimension yielded an alpha value of 0.85, confirming stable measurement of challenge and reward-related motivational elements. The learning effectiveness dimension showed a high reliability coefficient of 0.89, reflecting consistent evaluation of perceived knowledge acquisition and understanding. The overall reliability of the questionnaire reached 0.91, exceeding the recommended threshold of 0.70 and confirming the robustness of the instrument.

### Descriptive findings

Participants reported generally positive evaluations of the gamified immersive museum experience. Using a five-point Likert scale (1 = strongly disagree, 5 = strongly agree), the immersion dimension obtained a mean score of 4.23 (SD = 0.74), suggesting that respondents experienced a strong sense of presence and realism within the technological environment. The gamification dimension yielded a mean score of 4.16 (SD = 0.81), indicating that most participants appreciated challenges, rewards, and interactive game elements embedded in the exhibition. The learning effectiveness dimension recorded a mean score of 4.28 (SD = 0.69), reflecting that participants generally perceived meaningful knowledge acquisition and improved understanding during the museum visit.

These descriptive results suggest that the integration of immersive technology and gamification elements was positively received and perceived as beneficial for learning.

### Correlation analysis

Pearson correlation analysis revealed significant positive relationships among the three constructs. Immersion was strongly correlated with learning effectiveness ( $r = 0.63$ ,  $p < 0.001$ ), indicating that higher levels of perceived presence and realism were associated with stronger perceived learning outcomes. Gamification was also positively correlated with learning effectiveness ( $r = 0.59$ ,  $p < 0.001$ ), suggesting that motivational design elements contributed to enhanced knowledge acquisition. Additionally, immersion and gamification showed a moderate positive correlation ( $r = 0.55$ ,  $p < 0.001$ ), indicating that these two experiential components may reinforce each other in shaping user engagement and educational outcomes.

### Regression analysis

To further explore predictive relationships, multiple regression analysis was conducted. The results showed that both immersion ( $\beta = 0.41$ ,  $p < 0.001$ ) and gamification ( $\beta = 0.36$ ,  $p < 0.001$ ) significantly predicted perceived learning effectiveness. The regression model explained 52% of the variance in learning outcomes ( $R^2 = 0.52$ ), demonstrating substantial explanatory power. These findings indicate that immersive presence and motivational game mechanics are important determinants of perceived museum learning effectiveness.

### Finding

#### The role of immersion in museum learning

The findings demonstrate that immersion plays a significant role in enhancing perceived learning effectiveness. Participants who reported stronger feelings of presence and realism also reported higher levels of knowledge acquisition and understanding. This result aligns with experiential learning theory, which emphasizes the

importance of active engagement and situational experience in knowledge construction. Immersive technology appears to reduce psychological distance between users and cultural content, allowing visitors to experience artifacts and narratives in a more vivid and embodied manner. Such enhanced presence may facilitate deeper cognitive processing, thereby strengthening memory retention and comprehension.

### The motivational impact of gamification

The results also confirm the positive contribution of gamification elements. Challenges, rewards, and interactive tasks were positively associated with learning outcomes. This finding supports the notion that gamification enhances intrinsic motivation and sustained engagement. From a user-centered perspective, game mechanics provide structured goals and feedback loops, which help visitors maintain focus and actively participate in the learning process. Rather than passively observing exhibits, participants become active contributors to their own learning journey.

### Synergistic effect of gamification and immersion

Importantly, the correlation between immersion and gamification suggests a synergistic relationship. Immersive technology provides environmental realism and sensory engagement, while gamification introduces motivational structure and behavioral incentives. Together, they form a complementary system that enhances both affective involvement and cognitive engagement. This integrated effect may explain the relatively high explanatory power of the regression model. The findings suggest that museum learning effectiveness cannot be attributed to technology alone; rather, it emerges from the interaction between experiential immersion and motivational design.

### New revelation

The findings suggest that the proposed evaluation framework exhibits cross-cultural consistency across UK and Chinese participants, indicating its applicability in diverse museum contexts.

The first basic principle of this research is to improve learning effects. Therefore, a user-centric and participatory design approach is adopted. (Seale et al., 2021) (Wiggins et al., 2021) By directly asking people to explain their needs, or involving them in the design process with the help of designers, immersing them in the real world of users, Get people involved. In addition, this research focuses on the conceptual transformation of product to user experience, so it is necessary to use user experience design and tools and research methods, such as persona, empathy maps, user journey maps, explore innovative and simplified content, and test whether user experience tools will improve The interaction between people and products and services is more effective.

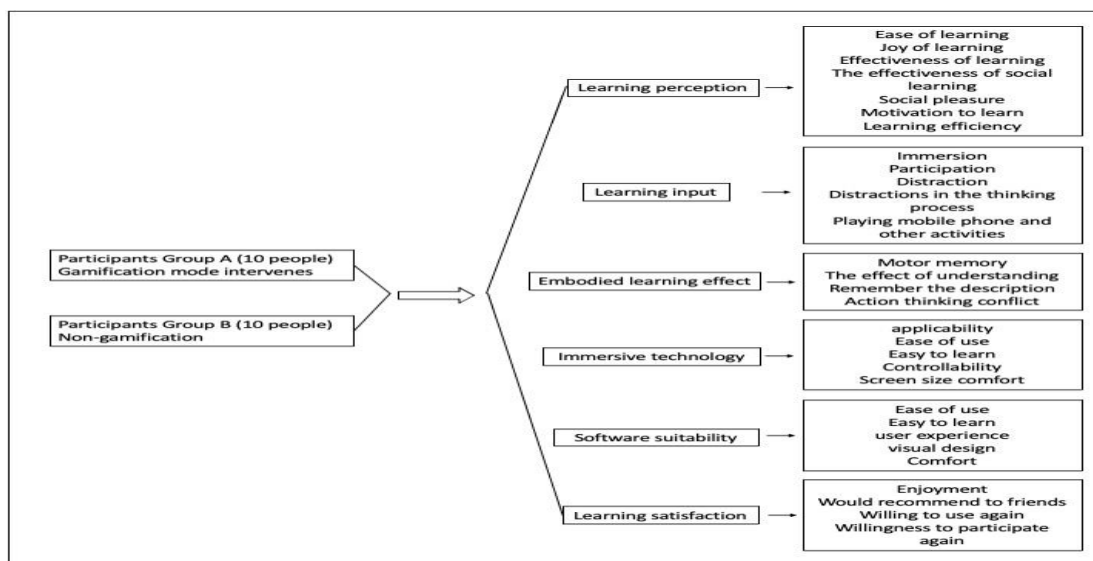


Figure 4 The evaluation framework of the proposed measurement items based on the application of gamification in VR (Yan, 2026)

This research needs practical auxiliary research, and needs to establish immersive technology and gamification prototypes for preliminary exploration. Create exhibitions and use multiple display formats for the same display content to form a control group to test the applicability of different immersive technologies and gamification methods to museum learning and their causal relationships. Conduct interviews with visitors to the exhibition, combined with questionnaire surveys, to gain a deeper understanding of the actual interactive experience. In addition, by inviting active users to form a focus group, they can get more sample cases and data more realistically. Due to the user's introduction and analysis of self-needs, there is a possibility of imperfection. Therefore, it is necessary to understand how things happen in their natural environment, that is, use observation methods to record the stay time, facial features, spatial features, behavior features, etc., of users' visits to the exhibition, and record their communication and information acquisition methods. Analyze and refine the data generated in the two stages, and draw the research conclusions of this stage. Testing and evaluating this research is very important for accomplishing goals, answering research questions, and measuring the impact of the entire project. Figure 4 shows the evaluation framework of the proposed measurement items based on the applicability of gamification in VR.

## CONCLUSION

This research relates to a relatively new field of research, and there are relatively few literature studies on the application of gamification and immersive technology in museum learning.

This study contributes to the literature by empirically validating a user-centered evaluation model for gamified immersive museum learning. Unlike previous research that examined technological features or engagement independently, this study integrates immersive presence and gamified motivation within a unified analytical framework. The findings provide evidence that both experiential and motivational dimensions significantly influence perceived learning effectiveness. This integrative perspective extends existing models of informal learning and digital education.

For museum designers and practitioners, the results highlight the importance of balancing technological immersion with structured game mechanics. Simply implementing advanced VR or AR technology may not guarantee educational effectiveness. Instead, careful design of challenges, rewards, and interactive narratives is necessary to maximize learning impact. Museums seeking to enhance educational outcomes should adopt a holistic approach that integrates immersive realism with meaningful participatory elements.

## Limitations

Several limitations should be acknowledged. First, learning effectiveness was measured through self-reported perceptions rather than objective knowledge testing. Future studies may incorporate experimental designs and pre- and post-tests to validate cognitive gains. Second, the study did not examine long-term retention effects. Longitudinal research could further investigate whether immersive gamified experiences produce sustained learning benefits. Finally, future research may explore cross-cultural differences and demographic factors to better understand variations in user response.

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