The Game of Heritage: Enhancing Virtual Museum Visits Through Gamification for Tourists

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Abstract **– This study delves into the integration of gamification within virtual museum experiences, focusing on its effects on visitor engagement and knowledge acquisition. In today's digital cultural heritage landscape, virtual museums emerge as innovative platforms for the dissemination of educational and cultural content. This research specifically assesses the impact of gamified elements namely points, badges, and leaderboards on enhancing the visitor experience in a virtual environment dedicated to the Himmapan creatures, a crucial aspect of Thai mythology exhibited at the Roitawarabarn Baandhawalai Museum in Chiang Mai, Thailand. Utilizing a quantitative methodology that includes the user engagement scale and a knowledge acquisition questionnaire, this study compares visitor interactions between gamified and non-gamified approach of the virtual museum. The findings reveal that gamification substantially enhances visitor engagement, especially in aspects such as focused attention and rewards, and significantly boosts knowledge acquisition when compared to non-gamified experiences.**

These outcomes emphasize the crucial importance of integrating gamification strategies within virtual museums to cultivate an experience that is interactive, engaging, and educational for visitors.

Keywords **– Virtual museum, culture heritage, gamification, virtual reality, tourism.**

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1. Introduction

Traditional museums draw the attention of tourists and visitors who want to learn about the cultural heritage or history of a specific location or theme and promote tourism by providing unforgettable and distinctive experiences that help people appreciate the locations they explore. According to their immersive experience and accessibility, the development of virtual museums has evolved into an effective method for promoting and distributing cultural heritage [53]. Given its technological advantages, virtual reality (VR) technology has received significant attention for enriching the experience of travelers in museums and places of cultural heritage [58], which includes museums [26]. Virtual reality is a 3D computer simulation that creates an imagined version of the real world [51]. Virtual reality enriches the quality of a museum exhibition with the incorporation of unique storytelling methods and immersive encounters that blend experiential education with inventive forms of entertainment and various other types of experiences [55]. Moreover, due to its attributes, virtual reality has found significant adoption within cultural tourism, as it aligns with the tourism industry's objective of furnishing travelers with distinctive and enriched experiences [8]. It bridges the distance gap between travelers and the destination by giving them information and increasing their comprehension of the location ahead of their physical trip [28]. Gamification features are used in a variety of simulations, including serious games, virtual reality, and augmented reality.

Likewise, in the fields of education and cultural communication, edutainment and gamification are commonly mentioned as popular and recurrent topics [35]. The incorporation of gamification elements into virtual reality environments not only functions as a tool for education but also resonates with core human desires, including the pursuit of rewards, status, achievement, expressiveness, and competitiveness [41].

Himmapan creatures are imaginary beings from Thai mythology, frequently represented as fascinating creatures with distinct qualities and features. Showcasing them in actual museums presents difficulties because their existence is dependent solely on mythology and creative interpretation rather than real evidence or artifacts. It appears challenging to properly depict these kinds of creatures in a real setting without depending significantly on artistic depictions or representations. Virtual museums are an easier approach to showcasing Himmapan animals given that they enable better artistic freedom and flexibility in depiction. Given the advantages of virtual museums, the researchers in this study intend to develop a gamified virtual museum of Himmapan creatures by acquiring information on Thai mythical creatures and studying how the gamified virtual museum affects tourists' experiences, engagement, and knowledge acquisition.

2. Literature Reviews

The literature review provides an overview of existing research and theories relevant to the integration of virtual reality (VR) and gamification in museum and tourism settings. By examining previous studies, this section aims to establish a theoretical foundation for understanding how VR and gamification can enhance visitor engagement, knowledge acquisition, and the overall experience in virtual environments. The review is organized into several key areas, including the use of VR in museums and tourism, the principles and applications of gamification, and the cultural significance of Himmapan creatures in Thai mythology.

2.1. Virtual Reality in Museums

The virtual model acts as an applicable cognitive instrument, allowing people to engage with 3D representations and things in a virtual setting. The use of this technology has potential uses in the field of cultural heritage, acting as a means for conservation, reconstruction, documentation, experimentation, and advancement [8]. Given its expanding utilization across various industries, virtual reality (VR) stands as a prominent subject in contemporary information management [54]. It provides a computer-simulated 3D world that develops digital representations of multi-sensory worlds that are virtual, which enhance museum content. It also improves the whole museum experience through incorporating museum-digital storytelling and delivering a sense of being immersed in cultural heritage showcases. In this virtual setting, tourists to the museum actively participate, feeling interactive sensations, and getting numerous illusory aspects of social interaction [30]. The term 'Virtual Museum' encompasses two types of VR technologies. The first type involves reconstructing an existing museum, enabling users to simulate immersive visits and explore artworks and archaeological discoveries. The second type involves creating a virtual environment from scratch, unrelated to existing structures, allowing users to navigate and observe the reconstruction of items [31]. Virtual museums provide new chances for exhibitions, promoting a unique engagement between the item being displayed and the tourists that traditional museums are unable to present. One of the primary characteristics of virtual museums is their capacity to transcend the boundaries of specific museums, integrating collections and resources from numerous organizations into a single presentation [16]. Hence, the format of virtual reality holds immense curatorial potential, enabling the creation of exhibitions entirely based on the curator's vision, free from the physical constraints of space and the types of items to be displayed [45], [46]. Table 1 provides the review of related studies on the application of virtual reality in museums.

Table 1. The review of related studies on the application of virtual reality in museums

Name	Country	Artwork	Type of artwork	Type of transfer to virtual environment	Type of information presentation
The Smithsonian American Art Museum “Beyond The Walls” [49]	United States	American art collections	Art collections	Real virtual museum	3D objects and videos
Städel Time Machine [50]	Germany	Art museums during the 19th century	Art collections	Real virtual museum	3D Object and Informative Pop-Up
In IL DIVINO: Michelangelo’s Sistine Ceiling [16]	Italy	Michelangelo’s Sistine Ceiling	Historical Places	Real virtual museum	3D Object and Informative Pop-Up
Guildford Castle VR [23]	England	Guildford Castle	Single Buildings	Real virtual buildings	3D Object, Informative Pop-Up and audio-visual hotspots
Visite virtuelle de l’Assemblée nationale [39]	France	French National Assembly	Single Buildings	Real virtual buildings	3D Object and Informative Pop-Up

2.2. Virtual Reality in Tourism

Virtual reality tourism involves digitally reproducing real attractions, locations, or tourist experiences, either as an introduction to physical visits or as an extension of prior consumer experiences. It serves as an administrative instrument for educating visitors and securing attractions, substituting actual visits, particularly in environmentally sensitive areas [21]. Furthermore, it stimulates programs aimed at increasing people's knowledge of environmental issues and promoting the preservation of the environment [20]. For instance, the Korean government employs a virtual reality tourist experience by utilizing a head-mounted display (HMD) as protection equipment for management at the Seokgulam Grotto hermitage and monastery complex, which is a World Heritage site [27]. Given its numerous potential and efforts to create the ideal virtual tourism experience, VR is increasingly viewed as another kind of tourism or a tool to improve visitor experiences, as opposed to a perfect replacement for traditional tourist visits [38]. The effectiveness of virtual reality as a promotional tool began to emerge, demonstrating its ability to enhance the perception of tourism content and consequently provide users with a more immersive experience [15]. The prospective potential to produce effective information has been established, especially as traditional information sources appear inadequate in supporting decision-making about tourism locations [36]. Virtual reality has been recognized for providing favorable feelings and sensations, which may affect opinions about specific tourist destinations, enhancing their level of acceptance [4], stimulating the desire to explore those locations, and strengthening these sensations in a real-world setting [7]. It has eliminated the distance barrier for visitors who are seeking knowledge about and comprehension of a destination before making decisions about purchases or organizing trips, altering how people travel and connect with a place [1]. According to research undertaken in Hong Kong and the United Kingdom, a significant number of potential visitors have encountered a certain kind of destination-related virtual reality ahead of their physical trips [56]. In their study, McFee *et al.* [37] contrast 360° video content with a more immersive VR experience, revealing that engagement plays a crucial role in shaping perceptions. Consequently, they advocate for the preference of immersive VR for information transmission over 360° videos, as it fosters a favorable destination image and heightens the intention to visit. Gibson and O'Rawe [19] discovered an increase in the possibility of exploring the actual location after exposure to it in a virtual setting.

To draw in new tourists as well as keep current ones, the tourism industry is deliberately developing tactics targeted at connecting and raising demand for locations [58]. According to research, the decision-making process for a given destination is significantly influenced by how visitors can acquire knowledge regarding the place in question, as well as the availability of memorable and creative experiences [25]. Hence, the growing significance of tourist destinations incorporating new tools in the tourism sector is apparent. Travelers are driven by novel elements that enable them to maximize their experience, consequently heightening the appeal for revisitation and suggestions to others [29].

2.3. Gamification

Gamification has found applications in a variety of fields, including cultural heritage, where it is a generally accepted method for promoting user enjoyment and motivation levels [57]. The uses of this tool include marketing destinations for tourism [59] protecting intangible and digital historical resources [3], as well as applying participatory approaches to deal with complicated heritage difficulties [47]. While it shares many common theories and development practices with computer games, it distinguishes itself from them. Gamification is regarded as a relatively recent advancement in the principles of computer game design, which have been studied since their inception [32]. It is the process of adding game features like prizes, tasks, and rankings to non-gaming contexts, which include management, education, tourism, and healthcare. Its major goal is often to increase the engagement of students with a given service or product [43]. Crucially, gamification does not imply the production of entire games; rather, it means using playfulness and playful tactics to deliver enjoyable activities to gain an intended goal [14]. By engaging in psychological requirements such as competence, connection, and independence, gamification encourages travelers to collaboratively create experiences, promoting favorable feelings, including well-being, and boosting participation. This method enhances travelers' ambition to connect with the community [2]. Furthermore, gamified mechanics encourage travelers to interact with digital platforms, either by contributing material for reviews or through badges. They contribute to the shared creation of value by enhancing service providers' effectiveness and ensuring service quality [2]. It is revealed that a variety of incentives motivate users to adopt gamified applications, including an interest in interactions, companionship, and assistance from social community members.

Various factors contribute to users' engagement with gamified mechanics. .

These include the desire for immersion and escapism into a fantasy realm, the inclination toward competition, utilizing other players to achieve personal goals through tactics like deceit or confrontation, the aspiration for achievement and authority by attaining game-defined objectives, the longing for leadership roles, and the yearning to partake in a communal experience, thereby gaining recognition and reputation within the player community [48]. Aparicio *et al.* [6] presented a gamification framework to increase involvement and motivation across different activities.

They suggested methods for rewarding people using game elements such as points, levels, and leaderboards, with an emphasis on independence, skills, and connection.

This framework helps to explain the positive benefits of gamification. Furthermore, [52] demonstrated that gamification improves educational encounters in museums by orienting tourists to particular learning goals throughout their visit to the museum. Nonetheless, it is significant to understand that, while gamification produces favorable outcomes, its success is significantly affected by the implementation setting and the user's specific characteristics. Poorly conducted gamification initiatives might provide negative outcomes [22]. Table 2 presents an overview of studies on gamification and cultural heritage context.

Table 2. An overview of studies on gamification and cultural heritage context

Name	Goals	VR types	Results
Fakhour, Azough, & Kaghat [17]	To create an engaging tour experience for tourists by utilizing augmented audio reality and gamification concepts in scavenger hunt platforms.	Augmented audio reality, gamification	Audio augmented reality and intense gamification methods encourage and motivate visitors to explore cultural heritage sites.
Lu, Yuan, Lin, & Yuan [34]	To introduces TouristGo, a mobile game model that suggests travelors the least crowded routes while also collecting their activity data.	Location-based mobile game	Travelors chose less crowded routes and saved time when utilizing TouristGo.
López-Martínez, Carrera, & Iglesias[33]	To enhance museum experiences through gamification techniques utilizing linked data and smart objects.	Semantic web and gamification	The study's findings encourage platform usage among users, suggesting its potential applicability and adaptability to of museums or cultural heritage organizations.
Cesaria, Ferdinando, et al. [11]	To boost students' interest in cultural heritage and improve their comprehension of local heritage, particularly Ferdinando, through the utilization of a Tangible User Interface integrated with gamification.	Tangible User Interface integrated with gamification	The prototype heightened students' motivation and engagement in the cultural heritage education workshop through the game's utilization.

2.4. Himmapan Creatures

According to the concept of the three worlds, or Traibhumi, the Himmapan forest is believed to exist at the base of Sumi Mountain, underneath Buddhist heaven. This forest is home to an array of magical animals and creatures from the Himmapan realm, which are products of imagination. Found in numerous Thai literary works and imaginative depictions, these extraordinary animals are an integral part of Thai culture. Himmapan creatures, often depicted as animals in literature or fantastical beings, possess distinctive physical traits unlike those of ordinary animals. They represent a fusion of various species, conceived by the imaginative minds of ancient artists. References to these creatures can be found in scriptures such as the Tripitaka or Traibhumi, which describe the Himmapan forest as their habitat. Tales of Himmapan creatures originate from ancient folklore and are presented in several written works.

Given that these creatures have never been seen in person, interpretations of them may differ [51]. Influenced by beliefs and cultures from diverse ethnic groups, Thailand's mythical animals are deeply rooted in its cultural heritage. These elements, drawn from sources such as China, India, and Cambodia, contribute to the unique character of Thai mythical creatures. Creatures like the Garuda and Naga, inherited from Indian culture, have been assimilated and transformed, becoming ancestors of Thai mythical creatures [44]. During the Sukhothai period, evidence concerning Himmapan animals is evident in stories linked to Buddhist scriptures referred to as the "Traiphum." Moreover, traces of mythical creatures can be observed in ancient art and murals at numerous historical places, albeit in limited quantities. Transitioning into the Ayutthaya period, further evidence emerged through decorative motifs, particularly observed in cabinets housing Buddhist scriptures and religious documents.

These motifs, which were used to store the Tripitaka and other Buddhist scriptures, depicted Himmapan animals. In addition, these animals were widely included in royal rituals, notably during cremation rites, with a significant increase in legendary animal sculptures compared to the Sukhothai era.

The Rattanakosin era witnessed a major increase in the production of sculptures and portrayals of mythological creatures as compared to previous times. This growth was supported by particular artists' increasing creativity, leading to a wide range of depictions.

3. Project - Virtual Museum of 3D HimmapanVR

This section introduces the 3D HimmapanVR project, which is focused on creating a virtual museum experience that brings to life the mythical Himmapan creatures from Thai folklore. The project leverages cutting-edge virtual reality technology to offer an immersive and interactive platform for tourists and learners alike. By integrating digital preservation techniques with innovative educational strategies, the 3D HimmapanVR project aims to enhance the accessibility and understanding of these culturally significant figures, making them accessible to a global audience in a dynamic virtual environment. The following subsections will delve into the specific objectives, digital collection processes, and the overall development methodology of the project.

3.1. Objective of the Project

The objective of the 3D HimmapanVR project is twofold: firstly, to digitize and preserve the art of Himmapan animals, thereby transforming this significant aspect of archaeological heritage into a virtual reality experience for tourists with an interest in Himmapan creatures. This initiative not only aims to enhance the accessibility of Himmapan animal art but also serves to promote the Roitawarabarn Baandhawalai Museum as a destination for cultural tourism. Secondly, the project seeks to leverage virtual reality as a tool for virtual-based learning, offering comprehensive insights into the digital preservation of Himmapan creatures through the incorporation of standardized metadata. Designed to cater to a diverse audience, including students, librarians, and historians, the application is intended to be a valuable educational resource that facilitates a deeper understanding of Himmapan creatures and their cultural significance. By achieving these objectives, the 3D HimmapanVR project endeavors to bridge the gap between traditional cultural heritage and modern technological advancements, thereby enriching the experience of learners and tourists alike.

3.2. Digital Collection of Himmapan Creatures

This section elaborates on the digitization process undertaken for the cultural heritage objects featured in the virtual museum, encompassing four primary types and fifteen sub-types of Himmapan animals as exhibited.

Owing to the wide variety of objects, our approach leverages several digital technology methods to capture and conserve each item of cultural heritage effectively. These methods include image scanning, photogrammetry, and 3D modeling, each selected based on the nature and characteristics of the objects in question. The detailed process and methodology applied are summarized in Table 3, which lists the heritage objects included in the 3D HimmapanVR project.

Table 3. List of heritage objects in the 3D HimmapanVR

Heritage Objects	Number of objects	Digitalization	Description
Wall Sculptures	16	Photogrammetry	Utilizes photogrammetry to capture detailed 3D models of wall sculptures depicting Himmapan creatures, ensuring accurate reproduction of intricate details. (Refer to Figure 1 for examples.)
Thai Dum Book and Paint Art	266	Image Scanner	Employs high-resolution image scanning to digitize Thai Dum books and paint art, preserving the fine artistry and coloration of each piece. (Refer to Figure 1 for examples.)
Digital Paint Art	56	Crowd Sourcing from the Artist	Gathers digital paint artworks through crowd-sourcing, allowing artists to contribute contemporary interpretations of Himmapan animals. (Refer to Figure 2 for examples.)
Animation	3	N/A-	Comprises a small selection of animations that bring to life the mythical essence of Himmapan creatures through dynamic visual storytelling. (Refer to Figure 2 for examples.)

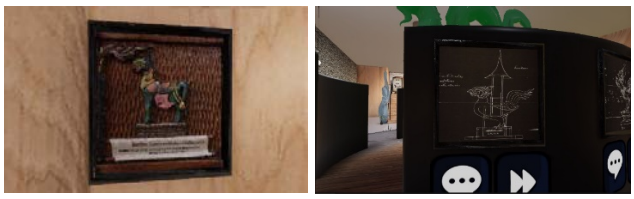

Figure 1. Digital wall sculptures (left) and Thai Drum Book and Paint Art (right)

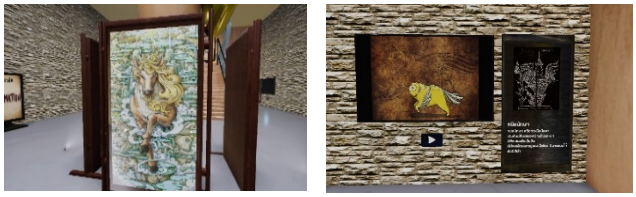

Figure 2. Digital Paint Art (left) and Animation (right)

3.3. Development Process of 3D HimmapanVR

The development process of the 3D HimmapanVR project was methodically executed, adhering to a comprehensive digital blueprint (referenced in Figure 3), which ensured a unified vision from its inception to completion. Utilizing agile software development methodologies [5], the team prioritized flexibility, continuous improvement, and the ability to rapidly adapt to changes throughout the project's lifecycle. This agile approach enabled the execution of regular iterations and testing phases, facilitating immediate feedback and necessary adjustments. These steps were crucial for enhancing the user experience and refining the interactive elements of the virtual reality (VR) environment.

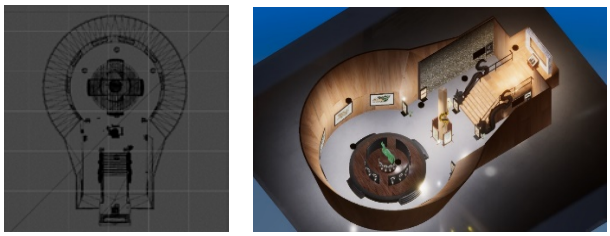

Figure 3. Digital Blueprint of 3D Himmapan VR

The creation of the 3D HimmapanVR project was fundamentally anchored in the Unity game engine, a decision underpinned by Unity's exceptional capacity for rendering high-quality 3D environments, animations, and interactive features. The engine's versatility empowered the development team to craft detailed and immersive representations of mythical Himmapan creatures and landscapes, offering an engaging and seamless user experience. Tailored specifically for the Meta Quest 2 headset, the project tapped into the advanced VR technology of the device to provide users with a deeply immersive and accessible exploration of Thai mythology.

During the development phase, a significant focus was directed toward optimizing the VR experience for Meta Quest 2, ensuring fluid performance and intuitive user interfaces. The collaborative effect of employing an agile development methodology, leveraging the robust capabilities of Unity's game engine, and utilizing the immersive potential of the Meta Quest 2, resulted in a dynamic and educational virtual reality experience. This harmonious integration of cultural heritage with cutting-edge technology marked the 3D HimmapanVR project as a pioneering approach to engaging with and understanding the enchanting world of Himmapan creatures, as demonstrated in the virtual museum shown in Figure 4.

Figure 4. Exploring Tourism in the Virtual Museum of 3D Himmapan VR

4. Objectives of the Study

The primary aim of this research is to explore the design of virtual museums and to assess the effectiveness of incorporating gamification concepts in enhancing visitor engagement and knowledge acquisition within the context of a virtual museum. Specifically, by developing a gamified virtual museum that showcases the Himmapan creatures—a crucial component of Thai mythology—this study seeks to understand the impact of game design elements on the educational and experiential outcomes of virtual museum visits. The investigation is intended to highlight the benefits of integrating gamification into virtual museums, with the objective of improving the educational and experiential quality of museum visits in a digital environment, particularly with an emphasis on tourism. To navigate this exploration, the study poses the following research questions:

RQ1: How does gamification in virtual museum experiences affect visitor engagement levels compared to non-gamified virtual museum experiences?

RQ2: What impact does gamification in virtual museums have on educational outcomes concerning Himmapan creatures and Thai mythology?

RQ3: How does knowledge acquisition from gamified virtual museum experiences compare with that from non-gamified museum experiences in the context of Himmapan creatures and Thai mythology?

These questions aim to unravel the complex impact of gamification on the virtual museum experience, spotlighting differences in engagement, educational outcomes, and knowledge acquisition between gamified and non-gamified settings. Through addressing these questions, the study seeks to provide valuable insights into the design and implementation of gamification strategies within the virtual museum context, offering a nuanced understanding of their potential benefits and challenges.

H1: Visitors experiencing the gamified virtual museum exhibit significantly higher levels of engagement than those experiencing a non-gamified virtual museum, highlighting the positive impact of gamification elements on visitor engagement.

H2: Educational outcomes related to Himmapan creatures and Thai mythology are significantly enhanced in the gamified virtual museum experience compared to the non-gamified experience, demonstrating the efficacy of gamification in improving educational content engagement.

H3: Knowledge acquisition concerning Himmapan creatures and Thai mythology is significantly higher among visitors to the gamified virtual museum compared to visitors to the non-gamified museum, underscoring the effectiveness of gamification in facilitating learning.

These hypotheses are devised to be tested through quantitative measures of engagement, educational outcomes, and knowledge acquisition, providing a structured framework for assessing the impact of gamification in virtual museum settings.

5. Research Methodology

This study adopts a quantitative approach utilizing an experimental design to compare user engagement and knowledge acquisition across gamified and non-gamified virtual museum experiences.

The experiment will involve two distinct groups: one experiencing the museum's virtual representation without gamification and another experiencing a approach with gamification elements. The primary aim is to evaluate the effect of gamification on user engagement and the enhancement of knowledge.

5.1. Participants

Participants will be sourced from the visitorship of Roitawarabarn Baandhawalai Museum. Eligibility criteria include being aged 20 years or older, willingness to participate in the study, and a basic proficiency in the use of digital platforms. The study will strive to enlist a representative number of participants who will be randomly allocated to each experimental group, ensuring diversity across various demographic profiles. To encourage participation and engagement, a monetary incentive of 100 baht (approximately 3 USD) will be provided. This incentive is designed to acknowledge the participants' contributions and to promote the provision of high-quality data within the questionnaire. The demographics of the participants are shown in Table 4.

Table 4. Demographic of participants

Categories	Data
Sample Size(N)	52
Mean Age (S.D.)	28.15 (4.79)
Male (%)	36 (69.23%)
Female (%)	16 (30.76%)
Has experience using virtual reality (%)	48 (92.30%)
No experience using virtual reality (%)	4(7.69%)

5.2 Instrument

To evaluate the effectiveness of gamification within the virtual museum environment, this study employed two distinct approaches to the virtual museum experience: a non-gamified approach, which lacks gamification elements, and a gamified approach, which incorporates various gamification elements. The primary distinction between these two approaches lies in the inclusion of gamification features in the latter.

This methodology facilitates a direct comparative analysis between the gamified and non-gamified experiences, specifically examining differences in visitor engagement and knowledge acquisition. By doing so, the study aims to isolate and assess the specific contributions of gamification strategies to enhancing the virtual museum experience.

Non-Gamified Approach: This approach of the 3D HimmapanVR virtual museum offers a traditional virtual museum experience, featuring virtual tours, informational text, and images of exhibits, devoid of any gamification elements.

It is designed to simulate the experience of visiting a physical museum, focusing on educational content delivery through conventional digital mediums.

Gamified Approach: Contrarily, the gamified approach integrates game design elements such as scores, badges, map progress, and leaderboards into the virtual museum experience.

These elements aim to motivate and engage users by fostering a sense of achievement and competition. The specifics of these gamification elements, including their design and implementation, are detailed in Table 5, with visual representations provided in Figure 5 and Figure 6.

Table 5. Game elements designed into the gamified approach of the virtual museum

Game elements	Definition	Design in Virtual Museum
Score Points	Points [11] awarded to users for completing tasks or interacting with exhibits within the museum.	Utilized to quantify visitor interactions, such as completing quizzes or exploring certain sections of the museum, enhancing engagement and providing feedback on user activity.
Badges	Digital icons or marks awarded for achieving specific milestones or tasks [10].	Awarded to visitors for accomplishments, such as visiting all exhibits or learning all facts about a specific creature, serving as a tangible recognition of user achievements.
Map progress	A visual representation of a user's journey through the virtual museum, showing areas explored and those yet to be discovered [40].	Guides visitors through the museum, indicating which areas have been visited and which remain to be explored, offering a personalized navigation experience.
Leaderboards	Rankings of users based on their scores, designed to foster competition by comparing achievements [9].	Displays visitor rankings based on their engagement with the museum, encouraging further exploration and learning, and fostering a sense of community and competition.

Figure 5. Design of game elements for score points (left) and Badges (right)

Figure 6. Design of game elements for Map Progress (left) and Leaderboards (right)

User engagement scale (UES) questionnaire: the user engagement scale (UES) questionnaire, employed from an established instrument [42], will measure the level of engagement experienced by participants. It encompasses aspects such as focused attention, perceived usability, aesthetic appeal, and reward, providing a comprehensive assessment of user engagement within the virtual museum environment.

Knowledge acquisition questionnaire: This custom-designed questionnaire aims to evaluate participants' acquisition of knowledge resulting from their virtual museum experience. Comprising twenty questions derived from the virtual museum's content, the questionnaire is provided by a lecturer from Chiang Mai University in collaboration with the museum's curator. This tool is instrumental in assessing the educational impact of the virtual museum on its visitors.

5.3. Procedure

The methodology of this study was structured into four distinct phases, designed to assess and compare the impact of non-gamified and gamified approaches within virtual museum experiences. Participants engaged with the study through digital questionnaires, facilitated via QR codes on their personal mobile devices, a process graphically represented in Figure 7. Below is an elaboration of each phase within the research procedure:

Step 1: Participant recruitment and pre-test: A total of 52 participants will be recruited to ensure demographic diversity, thereby enhancing the generalizability of the findings. Informed consent will be secured from all individuals. Prior to engaging with the virtual environment, a pre-test will be conducted to gauge participants' baseline knowledge of the museum content, establishing a control measure for subsequent comparison.

Step 2: Briefing and device preparation: Participants will receive a briefing on the use of the Meta Quest 2 VR equipment, the study's objectives, and the virtual museum experience, including a system check. The briefing will be identical for both the gamified and non-gamified virtual reality groups to prevent bias. This step will also include an explanation by the researcher, with an allocated duration of approximately 15 minutes.

Step 3: Field Tests: During the field tests, the Gamified Virtual Reality Group will interact with the virtual museum that includes gamification elements such as points, challenges, and rewards, while the Non-Gamified Virtual Reality Group will experience a approach without these features.

The objective is to critically assess the impact of gamification on user experience. This stage will last between 15 to 60 minutes, varying with individual participant engagement.

Step 4: Post-Test and Questionnaires: Following their museum visit, participants will complete the User Engagement Scale (UES) questionnaire to measure their levels of engagement. A post-test for knowledge acquisition will also be administered, reflecting the format of the pre-test to facilitate a comparative analysis. This final step is expected to take around 30 minutes.

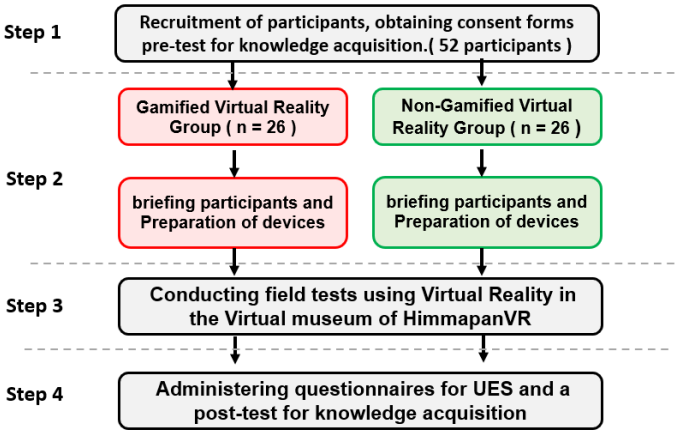

Figure 7. The four steps of research methodology

6. Results and Data analysis

This section presents the findings of the study, focusing on the impact of gamification on user engagement and knowledge acquisition within the virtual museum environment. The results are analyzed to assess the effectiveness of the gamified virtual museum compared to a non-gamified approach, with a particular emphasis on how these different approaches influence visitor interaction and learning outcomes. The data analysis includes statistical comparisons to determine the significance of the observed effects, providing insights into the role of gamification in enhancing the educational and experiential quality of virtual museum visits.

The following subsections will detail the specific results related to user engagement and knowledge acquisition.

6.1. Result of User Engagement

The analysis of the user engagement scale (UES) results, as presented in Table 6 and Figure 8, clearly demonstrates the effect of gamification on increasing user engagement within a virtual museum setting. Notably, significant enhancements were observed in the "Focus Attention" and "Reward" dimensions, with the gamified approach exhibiting superior performance over the control group. In particular, the gamified approach recorded a higher average score in focus attention, suggesting that the strategic integration of gamification elements more effectively captured and maintained the users' attention compared to the conventional non-gamified model.

Similarly, an appreciable improvement in scores within the "Reward" category for the gamified approach highlights gamification's efficacy in augmenting the user experience by imparting a sense of achievement and gratification. These findings emphasize the pivotal role of gamification in fostering deep and meaningful engagement among users in educational and cultural virtual platforms.

On the other hand, the dimensions of "Perceived Usability" and "Aesthetic Appeal" did not exhibit statistically significant differences between the gamified and non-gamified approach. This suggests that while gamification contributes positively to certain facets of engagement, its influence on aspects such as usability and aesthetic perception warrants further investigation.

This revelation points towards a sophisticated application of gamification techniques, indicating that specific elements may have distinct impacts on the comprehensive user experience. These insights advocate for a carefully balanced approach to implementing gamification within virtual museums, aimed at maximizing engagement while maintaining or enhancing usability and aesthetic appeal, to provide a holistic and enriching educational experience to visitors.

Table 6. Results of user engagement scale

UES dimension	Group	Mean (SD)	N	t	P-Value
Focus attention	Control (non-gamified)	2.88(0.71)	26	-2.42	.019*
	Experiment (gamified)	3.53(1.17)	26		
Perceived Usability	Control (non-gamified)	3.07(0.68)	26	-.867	.390
	Experiment (gamified)	3.23(0.58)	26		
Aesthetic appeal	Control (non-gamified)	3.11(0.76)	26	-.585	.561
	Experiment (gamified)	3.23(0.65)	26		
Reward	Control (non-gamified)	3.03(0.77)	26	-2.935	.005*
	Experiment (gamified)	3.61(0.63)	26		

*Note. * p-value less than 0.05.*

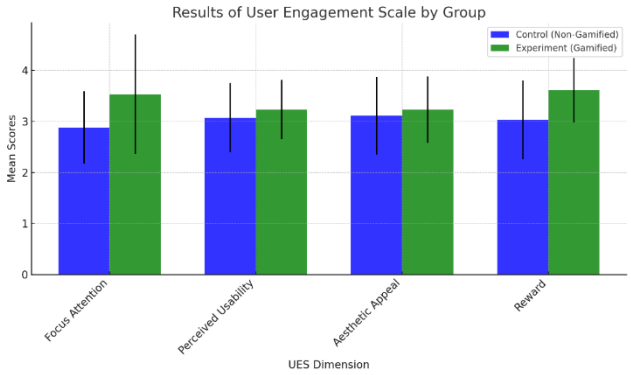

Figure 8. Results of user engagement scale by group

6.2. Result of Knowledge Acquisition

The assessment of the educational impact of gamification on virtual museum experiences was conducted through individual analyses of both the non-gamified virtual reality (Control) group and the gamified virtual reality (Experimental) group, utilizing pre- and post-test evaluations. Reflected in Table 7 and illustrated in Figure 9, significant gains in knowledge acquisition were observed within each group from the pre-test to the post-test phase. The experimental group demonstrated a substantial improvement in scores (Pre-test: M = 3.69, SD = 2.22; Post-test: M = 7.76, SD = 1.90), which indicates a notable enhancement in learning outcomes attributed to the gamification elements. Similarly, the control group also showed significant learning gains (Pre-test: M = 3.56, SD = 1.36; Post-test: M = 5.69, SD = 1.46). The statistical analysis, yielding t-values of -6.768 for the control group and -7.042 for the experimental group, with p-values of <.001 for both, demonstrates that the improvements in knowledge acquisition for both groups were statistically significant, with p-values well below the threshold of 0.05.

Table 7. Analysis of results from pre/post tests and t-test for gamified and non-gamified virtual reality groups

Group	Pre-test (SD)	Post-test (SD)	N	t	P-value
Non-Gamified Virtual Reality	3.56(1.36)	5.69(1.46)	26	-6.768	<.001*
Gamified Virtual Reality	3.69(2.22)	7.76(1.90)	26	-7.042	<.001*

*Note. * p-value less than 0.05.*

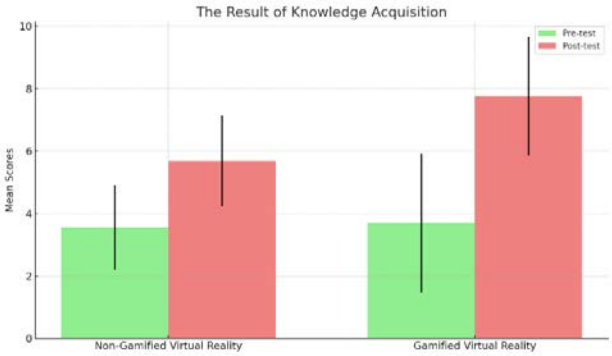

Figure 9. Results of knowledge acquisition by group

The comparative analysis of mean differences between the non-gamified virtual reality (Control) and gamified virtual reality (Experimental) groups, as depicted in Table 8, reveals significant findings regarding the impact of gamification on knowledge acquisition.

The control group, with a sample size of 26, exhibited a mean difference (post-pre) of 2.23 (SD = 1.68), indicating an improvement in scores after the intervention. However, the mean difference was notably lower compared to the experimental group, which achieved a mean difference of 4.07 (SD = 2.95) with the same sample size. This discrepancy highlights the enhanced efficacy of the gamified approach in facilitating learning outcomes.

Statistical analysis further corroborates these observations, with the control group's mean difference yielding a t-value of -2.33 and a p-value of .028, suggesting the improvements in the control group were statistically significant, yet comparatively modest. The absence of specific t and p-values for the experimental group in the provided data implies a focus on comparing the magnitude of change rather than direct statistical comparison between groups. Nonetheless, the greater mean difference observed in the experimental group underscores the added value of gamification elements in educational virtual reality environments.

Table 8. Analysis of results of the t-test comparison of mean differences between two groups: gamified virtual reality (experimental) and non-gamified virtual reality (Control)

Group (n)	Mean Post-Pre (SD)	Mean difference	Std. Deviation	t	P-value
Control (n=26)	2.23 (1.68)	-1.84	4.03	-2.33	.028*
Experimental (n= 26)	4.07 (2.95)				

*Note. * p-value less than 0.05.*

7. Discussion and Finding

In this section, the results of the study are interpreted and discussed in the context of existing literature. The discussion focuses on understanding the implications of the findings, particularly how gamification influences user engagement and knowledge acquisition in virtual museum settings. By comparing these results with previous research, the section aims to highlight the effectiveness of gamification in enhancing the virtual museum experience. Additionally, the discussion addresses the limitations of the study and suggests areas for future research. The following subsections will explore the specific effects of gamification on user engagement and educational outcomes.

7.1. The Effect of Gamification on Engagement in Virtual Museums (RQ1)

In investigating the impact of gamification on engagement within virtual museums, our analysis based on the user engagement scale questionnaire indicates that applying gamification techniques at Roitawarabarn Baandhawalai Museum in Chiang Mai, Thailand, significantly enhances visitor engagement, particularly in the dimensions of "Focus Attention" and "Reward". These findings corroborate previous studies [12], [18], highlighting gamification's effectiveness in increasing visitors' concentration and intrinsic motivation through mechanisms like competition and rewards. This supports the notion that gamification enriches the museum experience by fostering a heightened sense of achievement and engagement among visitors.

Contrastingly, our data reveal no significant differences in the "Perceived Usability" and "Aesthetic Appeal" dimensions between gamified and non-gamified groups. This suggests that while gamification excels in enhancing psychological engagement outcomes, such as competitiveness and motivation [13], it does not necessarily influence users' perceptions regarding the usability or aesthetic design of the virtual museum. These observations underscore the complexity of gamification's impact, indicating its strong influence on psychological and motivational aspects of visitor engagement but limited effect on aspects related to the virtual environment's usability and visual appeal.

7.2. The effect of Knowledge Acquisition of gamification in virtual museum (RQ2, RQ3)

Exploring the influence of gamification on knowledge acquisition within virtual museums (RQ2), the analysis demonstrates that both gamified and non-gamified virtual environments significantly bolster educational outcomes. This suggests that virtual museums are inherently effective at facilitating knowledge acquisition, regardless of gamification's presence. However, when comparing these two modalities (RQ3), it becomes evident that gamified virtual museum experiences yield a significantly more substantial improvement in knowledge acquisition than their non-gamified counterparts, as delineated in Table 8. The findings are in concordance with prior studies [12], [24], which corroborate that gamification can enhance educational outcomes within the context of virtual museums.

The implications of these results are manifold, emphasizing the considerable benefits of incorporating gamification elements into virtual museum designs. The superior learning outcomes linked to gamified experiences highlight how engaging visitors through challenges, rewards, and interactive content not only augments engagement but also markedly elevates knowledge acquisition. This underlines gamification's efficacy as a method to amplify the educational impact of virtual museum visits. Consequently, these insights serve as valuable guidance for museum curators and educators, suggesting that the strategic application of gamification can significantly enhance learning opportunities within virtual environments.

8. Conclusion, limitation, and future research

This study has successfully demonstrated the significant benefits of integrating gamification strategies into virtual museum experiences. By examining the differences between gamified and non-gamified virtual museums, particularly focusing on the Roitawarabarn Baandhawalai Museum's Himmapan creatures exhibit, it is clear that gamification can enhance visitor engagement and knowledge acquisition. Gamified experiences not only fostered greater attention and motivation among users but also led to superior educational outcomes compared to traditional virtual museum visits. These findings suggest that the judicious application of gamification principles can transform virtual museum visits into more immersive, engaging, and educational experiences.

While this research offers insightful contributions to the understanding of gamification in cultural heritage settings, it acknowledges certain limitations. The study's scope was confined to a specific cultural context and a singular virtual museum, which may limit the generalizability of the findings. Additionally, the quantitative approach, while robust, leaves room for a deeper qualitative exploration of user experiences and perceptions regarding gamified versus non-gamified interactions.

Future research should broaden the study's scope to include varied cultural contexts and more virtual museums, enhancing understanding of gamification's effectiveness. Additionally, examining the effects of UX and UI design on visitor engagement in gamified environments offers a critical avenue for deeper insights. Qualitative research exploring user narratives could further illuminate the impact of gamification on the virtual museum experience. Lastly, investigating new gamification techniques and their suitability for different virtual settings is crucial for improving the educational and experiential value of museum visits.

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