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Enhancing Engagement and Learning at Cultural Heritage Sites: The Impact of Gamification Strategies Based on Augmented Reality

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ABSTRACT

Augmented and virtual realities are revolutionizing user experiences by creating unique and immersive interactions. These technologies, which extend reality, are unlocking numerous possibilities, particularly in the tourism sector. In this context, gamification strategies are known for positively influencing consumer behavior introducing game aspects, such as rewards, competition, and narratives in non-game experiences. This paper aims to delineate current augmented reality and gamification advances in cultural heritage sites and analyze the impact of these technologies on tourist satisfaction, engagement, and learning. To achieve this, we surveyed 207 participants and analyzed the results through structural equation modeling (SEM). The results of our analysis show that introducing easy-to-use and useful AR technology is not enough to increase visitor engagement in a cultural heritage setting. The findings highlight a crucial intermediary role of gamification elements such as enjoyment and creative thinking. Thus, to be able to increase tourist engagement, managers of cultural heritage sites should not only implement beneficial and user-friendly AR technology, but also include gamification components, which focus on stimulating visitors' creative thinking and enjoyment of the gamified experience.

I. INTRODUCTION

In recent years, the intersection of technology and tourism has opened new avenues for enhancing visitor engagement and educational experiences at cultural heritage sites. Among the emerging technologies, augmented reality has gained significant attention for its potential to create immersive and interactive experiences. This paper explores the impact of AR-based gamification strategies on visitor engagement and learning at cultural heritage sites, emphasizing how these elements contribute to overall satisfaction.

The recent technological advancements applicable in tourism, has contributed to the rise of Tourism 4.0. This new era of tourism employs Industry 4.0 technologies, such as virtual reality, big data, artificial intelligence, and, notably, augmented reality, to create personalized and enriched travel experiences. This shift towards a more technologically integrated approach is driven by the principles of Industry 4.0, focusing on real-time data collection, modularity, and service-oriented design. The main aim of Tourism 4.0 is to primarily enhance the tourist experience through the use of immersive technologies. Augmented reality, a key component of Tourism 4.0, adds digital information onto the actual environment, giving consumers a more interactive view of their surroundings. This technology has been extensively adopted in various sectors, including retail, marketing, education, and entertainment. In the context of tourism, AR offers a unique opportunity to blend historical environments with digital interactive elements, thereby elevating the value of the tourist experience. AR is part of a broader category known as Extended Reality (XR) technologies. These technologies have valuable applications in the tourism industry but offer different levels of user immersion. Out of all the immersive technologies, AR has the highest potential for transforming the tourism sector in the short to medium term. This advantage is mostly due to its capacity to augment and integrate the user's environment with digital and interactive figures rather of canceling it out entirely, as in the case of virtual reality.

The effectiveness of AR applications in cultural heritage settings is substantially amplified when combined with gamification strategies. Gamification can be defined as the application of game-design elements in non-game contexts. It is a complex strategy composed of achievement features, social competition and

cooperation and immersion-related elements, such as customization and storytelling. In the tourism context, gamification refers to elements in the tourist experience that are typically seen in games, such as challenges, rewards, and missions. These elements can induce a positive psychological stress in the AR user, which, in turn, stimulates motivation. Gamification has been applied in various sectors, including education, marketing, and health care to motivate users to complete a certain task. In cultural heritage tourism, gamification serves as a powerful tool to transform passive observation into active participation. By incorporating gamification elements, heritage sites can create immersive environments that motivate tourists to explore, learn, and interact more deeply with the exhibits, ultimately leading to higher profits.

This paper aims to investigate the intermediary role of gamification elements in enhancing the impact of AR on visitor engagement, satisfaction and learning at cultural heritage sites. The primary research questions guiding this study are: (1) Can AR-based gamification strategies enhance the engagement of tourists in heritage tourism? (2) Can these strategies increase the perceived learning effectiveness and satisfaction of a cultural heritage tour?

To address these questions, the study utilizes an exhaustive methodological approach based on the Structural Equation Modeling. The analyzed constructs are derived from validates scales, including the Technology Acceptance Model (TAM) to assess perceived ease of use and usefulness of the AR technology, and the Gameful Experience Scale (GAMEX) to measure the enjoyment and creative thinking stimulated by gamification. Additionally, the study evaluates overall visitor engagement, satisfaction, and perceived learning, providing an in-depth view of the impact of AR-based gamification on the tourist experience.

The findings of this research highlight the crucial role of gamification in mediating the relationship between AR technology and visitor engagement. The results suggest that managers of cultural heritage sites should not only focus on the technical aspects of AR implementation but also on designing gamification strategies that foster an enjoyable and intellectually stimulating experience for visitors. By doing so, cultural heritage sites can significantly enhance visitor

engagement, satisfaction, and learning, creating more compelling and memorable tourism experiences.

In conclusion, this paper contributes to the growing body of literature on the integration of technology in tourism by providing empirical evidence on the effectiveness of AR-based gamification strategies. It emphasizes the significance of a human-centered design approach that promotes visitor enjoyment and creative thinking, providing useful insights for both scholars and practitioners in the field of cultural heritage tourism.

II. LITERATURE

A. AUGMENTED REALITY IN TOURISM

1. Tourism 4.0

The study of our past has long captivated humanity and will undoubtedly remain so. History repeats itself, and there is no better way to foresee the future than by looking at the past. This is probably why humans have an intrinsic desire to understand past events. The primary location for connecting with and comprehending our history is by visiting the sites where significant events unfolded, preserving our cultural heritage.

In recent years, researchers have tried to find ways to mix the past with the future by incorporating new technologies into cultural heritage sites. This wave of research has created a new tourism framework known as Tourism 4.0 (Permatasari et al., 2020). In this new era of tourism, the focus is centered on the implementation of innovative technologies aimed at increasing tourist engagement. Tourism 4.0 is a new tourism value ecosystem built on an increasingly technologically advanced service delivery framework and supported by Industry 4.0 principles such as virtualization, decentralization, interoperability, real-time data collection and analysis capabilities, modularity, and service-oriented design (Pencarelli, 2019).

For a clearer comprehension of what researchers and practitioners envision for Tourism 4.0, it's beneficial to delineate the various phases of tourism.

Before the railway and steam engines were invented, people traveled for trade, pilgrimages, medical care, and other objectives other than pleasure and amusement. This era is known as Tourism 1.0 (Astanakulov & Goyipnazarov, 2022).

Tourism 2.0 encompasses developments such as steam engines and railways. After the industrial revolution, greater international trade and production, as well as the emergence of new technologies like radio and television, raised the visibility of desired tourist destinations. Tourism 2.0 has developed quickly, mainly because of the advent of specialized firms offering new tourism services. During this time, the primary goals of Tourism 2.0 were to educate the public about tourist attractions, inspire people to travel, and develop a culture and aptitude for travel. Additionally, at this time, people were able to allocate more free time for travel and hobbies due

to the Trade Union Movement and better living and working conditions (Dekhtyar et al., 2021).

Tourism 3.0 is regarded as a business revolution in the travel and leisure sector, characterized by the expansion of mass tourism aided by the development of digital, user-friendly platforms such as social networks, mobile applications, and operator websites. This enabled travelers to look up information, plan, and book activities before their trip. Facilitating communication between tourist participants and guaranteeing efficiency and consumer happiness are the primary objectives of Tourism 3.0 (Astanakulov & Goyipnazarov, 2022).

The idea behind Tourism 4.0 is to leverage "Industry 4.0" technologies—like virtual reality, big data, artificial intelligence, autonomous transportation, autonomous robots, and co-bots—in the tourism industry to increase the added value of travel. Consequently, the goal of Tourism 4.0 is to guarantee the efficiency of tourism in addition to fostering the creation of unique travel experiences and a cooperative model amongst process players (Goriup & Ratkajec, 2021). A novel trend regards personalized tourism in creating a unique experience for each consumer by tailoring services to their requirements and preferences through the use of digital technologies to process and analyze data. Thus, another characteristic of Tourism 4.0 is the shift from organized tourism to individual tourism.

Tourism has always been a highly technology-dependent sector, so it didn’t hesitate to jump on the arising Industry 4.0 trend (Stankov & Gretzel, 2020). A large portion of the production and delivery of tourism-related goods and services is currently in the process of being fully automated due to the implementation of Industry 4.0 technologies, such as artificial intelligence (AI), the Internet of Things (IoT), virtual and augmented reality systems, big data analytics, or blockchain (Ivanov, 2020).

It has been established that Tourism 4.0 technologies have the potential to significantly improve visitor experiences (Neuhofer et al., 2013; Wang et al., 2011). Some applications of Industry 4.0 technologies in tourism include autonomous agents such as AI voice assistants (Cohen & Hopkins 2019), robots (Murphy et al. 2019; Tussyadiah & Park 2018) or AI digital avatars.

There are a lot of studies about the possible uses of these technologies in the tourism industry, but most Industry 4.0 solutions have not been developed primarily to

benefit travelers. Sometimes their design even fails to fulfill its intended function, which is likely to have a negative impact on visitors' experiences. Frequently, the benefits that travelers hope to gain are compromised by the use of these technologies (Gretzel, 2014; Dickinson et al., 2016; Pearce & Gretzel, 2012). Some negative consequences of their use have been reported to be technological stress, overload of data, alienation, and detachment from the tourist experience. Other studies highlight that these technologies have the potential to diminish the quality of the tourist experience (Buhalis et al., 2019; Tussyadiah, 2017), disrupt the core of the visit, or even cause physical harm (Gretzel, 2010).

These negative effects can ultimately cause the destruction of value in the tourist experience (Dinçer et al., 2020; Kim & Qu, 2014; Lee et al., 2014). Frequently, Tourism 4.0 solutions are neither sustainable nor people-oriented; instead, they primarily focus on the effectiveness of new technical solutions (Pencarelli, 2019). In this context, the significance of a human-centered design methodology that prioritizes fostering positive impacts on tourists' experiences becomes apparent (Stankov & Gretzel, 2020).

2. Extended Reality Technologies

In Tourism 4.0, augmented reality (AR), virtual reality (VR), and mixed reality (MR) stand out as key technologies. They fall under the broader category known as Extended Reality (XR), which encompasses all immersive technologies. XR serves as an umbrella term, covering AR, VR, MR, and any future innovations in this domain. These technologies enhance our reality by either blending virtual elements with the real world or by providing entirely immersive experiences.

VR provides total immersion in a three-dimensional digital environment. To experience this transition, a VR headset is required, like the Oculus Rift or Samsung Gear VR. Realistic sounds, visuals, and other experiences simulate the user in a digital environment (Farshid et al., 2018).

AR provides a way to overlap a digital world over the real one. This reality can be accessed via smartphones, wearables, or smart glasses. The most recent example is Apple’s ProVision. Augmented reality uses technology to provide consumers with

an additional layer of information by combining their perceptions of the actual environment with virtual components produced by computer programs (Farshid et al., 2018). The additional AR layers of reality can manifest in various forms, including sensory inputs such as sound, video, graphics, or haptics, as well as data-based inputs.

A less known subtype of AR is mixed reality (MR). MR technology, also known as hybrid reality, not only merges the real world with a digital one but also allows users to interact with the virtual elements. To experience this technology, smart glasses - lenses with special screens and sensors to track the user's immediate environment - are needed. Using specialized technology (such as cameras, microphones, and GPS), smart glasses record the real world and incorporate virtual data that is either kept in the device or obtained through mobile internet technologies (Khalid Obeidy et al., 2018). An example of smart glasses is Microsoft's HoloLens 2. Moreover, with the advancement of nanotechnology, these devices will become smaller and more powerful. It is predicted that future iterations will offer even more realistic experiences, along with more comfortable glasses (Rauschnabel, 2022). Compared to AR, MR gives consumers a more immersive experience whilst keeping them linked to the actual world.

These technologies have gained a lot of popularity in the last decade, as evidenced by the unforeseen growth of their markets. The immersive B2C market was valued at 31.1 billion US dollars and is projected to grow at an annual compound rate (CAGR) of 23.5% (Topic: XR: AR, VR, and the Metaverse, 2024). Among these technologies, the AR market stands out as one of the largest segments, with an estimated market size of 21.1 billion US dollars (Topic: Augmented Reality (AR), 2024). Indeed, augmented reality is widely believed to be one of the most innovative technologies in driving new opportunities for businesses globally (Liu et al., 2023). This is because of AR's ability to seamlessly integrate 2D or 3D digital content into the user's perception of the real world (Yuen et al., 2011).

3. Extended Reality in Tourism

This paper will primarily focus on the application of AR and gamification strategies in tourism. In addition to giving tourists more individualized and immersive travel

experiences, these technologies improve the sustainability and efficiency of tourism management and operations (Shizhen et al., 2023).

According to Büttner (2017) and Rehrl et al. (2008), AR is a digital extension of a person's sight and hearing that is generally accessed via smart glasses, tablets, laptops, and mobile phones. According to Azuma et al. (2001, p. 34), it is described as an application that "supplements the real world with computer-generated virtual objects that appear to coexist in the same space as the real world." While research on AR has been around since the 1960s in computer science (Wahba, 1965), the practical application of AR in public use has been limited by facilities and technology. Following the 2007 release of the iPhone, smartphones—which are crucial for enabling accessibility for AR applications—gradually dominated the mobile device market (Carmigniani et al., 2011). Nevertheless, the general population remained unaware of this technology and AR programs. Researchers have been examining this new and innovative technology since the "Pokémon Go" AR game's 2016 surge in popularity, which caused awareness and eagerness to download AR applications (Rauschnabel et al., 2017). This AR game's popularity demonstrated consumer interest in AR and its potential in travel and leisure applications (Cranmer et al., 2017). This popularity is confirmed by the forecasted growth of the AR market of 67.33% from 2023 to 2027 (Statista, 2024). It is unsurprising that the majority (46%) of the users of Pokèmon Go were between the ages of 18 and 29. Meanwhile, around 22% of the users were between the ages of 13 and 17, with 6% over the age of 50. These statistics indicate that half of the game's multimillion audience is made up of Gen Z gamers.

AR can be classified into two main categories: GPS-based AR and marker-based AR. Although GPS-based augmentation of the physical world appears to be the most sensible way to use AR in tourism, it has been argued that current devices do not have the processing power or accuracy to project meaningful AR overlays that would improve the visitor experience (Gherghina et al., 2013). However, marker-based AR enhancements are activated by "markers" that attach virtual material to particular objects or images; as a result, they were thought to be the more appealing types of AR enhancements. A third type of AR application is site-based, which augments fixed installations for on-site users (Williams & Mascioni, 2017).

A vast array of studies are currently conducting reviews of both virtual reality and augmented reality. Although they may appear similar at first glance, they represent distinct technologies. AR enables users to engage with the real-world environment by overlaying digital elements onto it. In the realm of tourism, users must be physically present to fully leverage this technology. While VR fully immerses users in computer-generated environments, providing a completely virtual experience without the need for any physical component (Bretos et al., 2023). This crucial distinction suggests that rather than replacing the viewers' experience, augmented reality would be more suited to enhancing it (Neuhofer et al., 2013). Therefore, those organizations that seek to enhance rather than replace visitors' experiences could benefit from implementing AR-focused strategies, rather than VR-based ones.

He, Wu, and Li (2018) recognize that augmented reality (AR) is one of the most transformative inventions in recent years. This technology has increasing applications in immersive consumer experiences and virtual marketing campaigns (Cranmer et al., 2020). Guttentag (2010) highlights AR's role in destination development, enhancing authenticity, and offering immersive travel experiences.

In tourism, AR applications contribute significantly to education, marketing, and enhancing visitor experiences (Loureiro et al., 2020). AR offers travelers more information, engaging activities and affects the psychological picture of the destination (Fan, Jiang, & Deng, 2022). The technology creates unforgettable travel experiences, improves overall satisfaction (Jiang et al., 2022), and enhances cognitive appreciation of destinations (Chung et al., 2015; Jung et al., 2015).

Compared to AR and VR, a smaller body of research focuses on mixed reality (MR). However, in recent years, this AR-based technology has gained importance within the context of tourism. Indeed, the travel industry can benefit from MR in terms of marketing, economic advantages, tourism promotion, and organizational benefits (Buhalis & Karatay, 2022). According to research, employing MR technology in heritage tourism can boost visitors' curiosity and engagement while also helping to preserve cultural assets (Yung & Khoo-Lattimore, 2019). MR technology is also gaining popularity as a means of co-creation within the tourism experience (Han et al., 2019). By providing educational and engaging content, MR

has the potential to completely transform visitor satisfaction and interaction (Kaplan & Shiff, 2016).

A recent study focusing on Gen Z tourists has demonstrated the utility of MR in increasing value co-creation, engagement, and the duration of visits to cultural heritage sites. As a consequence, neglected cultural heritage sites that receive little traffic have the opportunity to boost visitor flows by utilizing MR technology to make visits entertaining through co-creation and innovation (Buhalis & Karatay, 2022). This technology holds particular appeal for this demographic group, given their innate ability to navigate both physical and digital environments (Fan et al., 2019).

The literature indicates that MR offers enormous potential to improve the visitor experience in the tourism industry in general. A smaller body of research also shows its benefits in cultural heritage tourism (Ioannides et al., 2017; Bekele et al., 2018; Plecher et al., 2019). The tourism industry, particularly focused on cultural heritage, seeks new and creative ways to attract tourists by utilizing the latest technological advancements (Tscheu & Buhalis, 2016). MR is expected to enable tourists to co-create value through blended experiences, reenact animations, and interact with artifacts from cultural heritage. To support these hypotheses, a recent project incorporating MR into a cultural site in Rome resulted in an immersive visit. This visit combined experiential learning and entertainment, effectively increasing visitor presence and satisfaction (Trunfio, 2020).

4. Cultural Heritage Tourism

Cultural heritage refers to the legacy of physical artifacts, tangible and intangible aspects of society that are inherited from past generations. It encompasses tangible cultural heritage, such as buildings, monuments, and artwork; intangible cultural heritage (traditions, practices, rituals, and languages); and natural cultural heritage, which includes landscapes, ecosystems, and biodiversity.

The definition has changed through time. As UNESCO notes, “Originally, it referred only to masterpieces of artistic and historic value; now it is used more

broadly and covers everything that has a particular significance to people" (UNESCO and IFT, 2007, Unit 1: 3).

Cultural heritage is one of the most important drivers of tourism. It is evident that cultural heritage resources can contribute to tourist development in a way that is unmatched due to their unique qualities (Puczko & Ratz, 2007). Cultural heritage tourism, for instance, is defined from a practitioner's perspective by the USA's National Trust for Historic Preservation as:

> "Traveling to experience the places, artifacts, and activities that authentically represent the stories and people of the past and present. It includes cultural, historic, and natural resources. Good cultural heritage tourism improves the quality of life for residents as well as serving visitors." (National Trust for Historic Preservation, 2013)

Another definition that highlights an element of learning or education in cultural heritage tourism is the following: "cultural heritage tourism encompasses built patrimony, living lifestyles, ancient artifacts and modern art and culture" (Timothy, 2011). This definition suggests that the essence of cultural tourism is traveling to experience the contemporary narrative of the visible evidence of the past and its significance today.

Cultural heritage is one of the world's most important and widely used tourist resources. Simultaneously, heritage tourism is the primary motive for travel. Numerous destinations seek to leverage their built environment and other forms of heritage to drive socio-economic progress through tourism (Timothy, 2014). Lately, there's been a broad acknowledgment of the importance of incorporating cultural experiences and historical elements into tourism offerings. This recognition stems from the understanding that this facet of the tourism experience is among the most essential ways to distinguish destinations. Consequently, there's been an increase in the frequency of access to heritage sites, along with the planning of special exhibitions, events, and festivals (Kaminski et al., 2013).

5. Augmented Reality in Cultural Heritage Tourism

The new generations, specifically Generation Z, are revolutionizing the tourism industry by demanding the co-creation of transformative experiences. Cultural heritage professionals need to be aware of the requirements and preferences of Generation Z to foresee the occurring trends and maximize return on investments (Buhalis & Karatay, 2022). One of the most profitable ways to enhance the co-creation of the travel experience is indeed through the use of extended reality technologies. According to McKercher, cultural tourism has become a key driver within the tourism industry, driven by a shift in tourist preferences towards seeking meaning-creation and learning opportunities to enhance their cultural awareness (McKercher et al., 2006).

As a result, many cultural tourist attractions have started to find new ways to offer tourists enhanced experiences with co-creation elements to increase their enjoyment. One of the main factors encouraging tourists to interact with cultural tourism offerings was found to be self-motivated and self-guided learning (Ismagilova et al., 2015). Audio guides and more contemporary innovations like mobile applications that can tailor material and narrative to a user's interest and pace are notable examples of how self-guided and self-motivated learning have advanced.

Nevertheless, numerous studies highlight the benefits of augmented reality (AR) and virtual reality (VR) in the cultural tourism context, as they present new opportunities to transform the visitor experience (Jung et al., 2015; Chung et al., 2017; Raptis et al., 2018). AR and VR have been positioned as viable ways to improve the visitor experience in cultural tourism by providing an additional layer of virtual enhancement, thereby enhancing the co-creation of value.

Tourists are evolving into "active participants" rather than "passive observers," as noted by Prahalad and Ramaswamy (2004). This transformation underscores the significance of strategies centered around interactive experiences. Recent advancements in augmented reality (AR) and virtual reality (VR) technologies have unveiled a number of new interaction frameworks for experiencing cultural heritage. This development has given rise to the concept of interactive thematic virtual environments (ITVE). In these environments, tourists are immersed in an

alternative world where they can interact with stories associated with an artifact or artwork, resulting in a tailored cultural experience (Bozzelli et al., 2019).

Augmented reality has found numerous applications in the realm of cultural heritage, primarily leveraging the integration of virtual information into the physical reality experienced by visitors. Examples of AR usage in cultural heritage include the presentation of textual descriptions and graphical representations alongside physical objects, the overlay of digital restorations onto historical artifacts, the integration of virtual characters into real-life settings, and various other innovative techniques.

Over time, a multitude of cultural heritage sites have developed AR solutions, each pursuing its own distinct objectives. Among these objectives, some AR experiences aim to showcase the restored versions of the sites. In 2001, the Archeoguide project in Olympia, Greece, made it possible for tourists to stroll through the historic city and observe original buildings and structures next to archaeological remnants (Vlahakis et al., 2001). While another cultural heritage site developed an app for guided tours in an archaeological park in Carnuntum, Austria (Weisz, 2023). This AR app provided users with a journey through time to relive the Roman military camp by incorporating new interactive experiences. The Jumigies App (France, 2012) enables users to virtually tour the Abbey of Jumieges and see it as it was before it was partially destroyed (Pipitone, 2013).

In other cultural contexts, the emphasis shifted towards interactive guides. The Speaking Celt in the Museum of Celtic Heritage, Salzburg, used AR to guide visitors through the museum and explain and tell stories about objects. As a result, the user has a highly intimate and participatory experience where they can identify with the story (Plecher et al., 2019). While in Hallein, Austria, the Museum of Celtic Heritage introduced an app that offered an interactive guide to the museum. After scanning a target that is placed close to the artifacts, the avatar of a Celtic warrior appears in the windows. The avatar provides information on the way of life, individual tales, and specifics about the objects. Because the story is given from a personal and emotional point of view, it has additional importance (Schneeweis, 2016). A more recent project called ArkaeVision Art uses AR to animate the scenes depicted in the many tomb slabs at the Museum of Paestum as well as the characters,

who converse with the viewer directly (Bozzelli et al., 2019). An additional investigation examined the efficacy of an AR guide in enhancing understanding and learning outcomes of the culture of a martial temple in Taiwan (Chang et al., 2019).

At other cultural sites, the primary focus was simply to enhance and animate objects to facilitate educational experiences. Specifically, The Franklin Institute, Philadelphia, U.S.A., has included an "AR Terracotta Warriors" experience where visitors can see the actual representations of the artifacts, sculptures, and weaponry to have a deeper understanding of the enigma surrounding the Terracotta Army (Paula, 2022). The app KeyARt is known for its image recognition ability and provides additional information about the specific artwork. It is accessible at the world's most frequented museums, including the Louvre, the Metropolitan Museum of Art, the Getty Center, the Art Institute of Chicago, the Vatican Museums, the National Gallery, LACMA, and Tate Modern (KeyARt - *La Nuova App per La Visita Al Museo in Realtà Aumentata,* 2018). In Milan, the Museum of Augmented Urban Art has inaugurated an open-space gallery featuring over 50 urban artworks, where visitors can view virtual art through their smartphones (MAUA Museum, n.d.).

In a 2013 study, Puyuelo examined augmented reality (AR) as a means of improving accessibility to cultural and architectural monuments. Through the identification and visualization of 3D models, the AR application assisted users in comprehending a UNESCO World Heritage site. Positive evaluations of the experience indicated that it was more enjoyable, interactive, and appealing visually and figuratively (Puyuelo et al., 2013).

The literature illustrates the potential of AR technologies to transform the way cultural heritage is experienced, making it more interactive, educational, and accessible to a broader audience.

B. GAMIFICATION

1. Definition and Impact of Gamification

Gamification is the process of incorporating game strategies and elements into non-game activities and circumstances (Robson et al., 2015). It is the use of game design

components including missions, rewards, rankings, and entertainment in non-game sectors such as education, marketing, tourism, and health care (Deterding et al. 2011). Businesses that utilize gamification strategies primarily aim to motivate users to achieve their goals, ultimately serving the particular objectives of the implementing organization (Burke, 2014). Gamification activities allow individuals to engage with the destination in an interactive manner (Xu et al., 2017). Gamification involves actions that create psychological strain, allowing users to focus on the destination or attraction without external interference. Gamification's missions and challenges generate positive stress, known as eustress, which can lead to good emotions like joy, contentment, and enthusiasm (Snodgrass et al., 2016).

Gamification strategies have had a great surge in the last few years, especially in education-related contexts (Liapis et al., 2019). Gamification in education and learning is a set of procedures and activities that use unique game mechanics to solve educational and learning difficulties (Kim et al., 2018). Notably, in the sphere of education and learning, a number of experimental studies have empirically investigated the impact of gamified learning approaches on learning outcomes as well as motivating aspects such as enjoyment and flow (Foster et al., 2012; Goehle, 2013; Hanus & Fox, 2015; Domínguez et al., 2013). The literature demonstrates that gamification strategies contribute to rendering learning experiences more appealing, captivating, and efficacious. Consequently, the enhancement of motivation and engagement within educational frameworks emerges as a primary driver for the application of gamification techniques (Caponetto et al., 2014).

Another important context in which gamification strategies have grown in number is marketing. Gamification in marketing tries to reach clients in a playful manner in the company's external environment. However, the purpose is not to force customers to play these games. Rather, businesses are attempting to use gamification to make processes more enjoyable and amusing for customers, resulting in greater customer loyalty and retention (Asquer, 2013). Indeed, gaming mechanisms allow clients to become addicted to the firm and, hence, more loyal to its products or brand (Majerova et al., 2013).

The future of gamification is likely to expand, particularly in three key areas, which include expanding game system interfaces, enhancing performance, and

incorporating virtual and augmented reality (Kapp, 2013). Among the most recent technological developments, virtual and augmented reality stand out as having the most potential for growth, with gamification positioned to have a significant impact on the sector of extended realities (Jacobs, 2017).

2. Gamification Features

Gamification strategies consist of several key features. A recent study by Rohan et al. (2020) identified a total of 27 gamification elements. These components can be grouped into three main categories: achievement, social, and immersion. The ultimate goal of each element is to motivate individuals to perform particular actions, such as learning or interacting with brands, depending on how gamification is applied in a given context. Motivation is expressed by a person's choice to take part in a task, as well as the degree of effort or determination in that action (Garris et al. 2002). Motivation can be divided into two main clusters: extrinsic and intrinsic motivation (Deci, Koestner & Ryan, 1999; Ryan & Deci, 2000). Extrinsic motivation considers external incentives, such as rewards, to increase motivation. Contrarily, intrinsic motivations regard the internal drive for personal satisfaction. Gamification merges these two motivations by using extrinsic rewards such as points, levels, and badges to enhance engagement as well as intrinsic motivations to foster feelings of belonging to a group, mastery, and autonomy (Muntean, 2011).

The first category comprises all achievement- and progression-related features of gamification. These elements challenge and reward the user in the case of the achievement of a particular task (Xi & Hamari, 2019). The most common types are game points, levels, badges, progress bars, and leaderboards. Users earn points by completing tasks, achieving goals, or engaging in desired behaviors within the gamified system. As they accumulate points, users can advance to new levels of the gamified experience. Badges are visual symbols or icons awarded to users upon reaching significant milestones. It has been proven that the use of points, badges, and leaderboards improves the motivation of the users, especially in learning processes (Prieto Andreu, 2020). A recent study indicates that higher education students, approximately 20 years old, value certain gamification elements.

Feedback, levels, points, and missions were particularly highly regarded among all gamification components (Garcia-Iruela & Hijon-Neira, 2020).

The second category regards social-related features. Notably, the social aspect, which is defined by player interaction and interconnection, is extremely important in games (Ling et al., 2005). Factors known to influence player behavior include competition, which fosters a spirit of rivalry; social interaction, which promotes bonds and connections among participants; and cooperation, which encourages collaborative efforts toward shared goals (Sweetser & Wyeth, 2005; Yee, 2006).

The final category consists of the immersive-related features, which keep users engaged in an enjoyable gamified environment (Yee et al., 2012). The most relevant elements include storytelling, narrative, avatars, and customization. The concept of immersion is generally related to experiences of transportation and time loss (Jennett et al., 2008; Qin et al., 2009). Games pull the user into a virtual world, causing higher levels of engagement (Naul & Liu, 2019). Traditionally, narratives are known to keep the reader's interest since they are less authoritative and allow for freedom of interpretation and negotiation of meaning. Narratives in games differ from traditional novels, comics, or plays in that they are more participatory, less fixed, and usually controlled by the player (Qin et al., 2009). Other research has proven that immersive storytelling coupled with reflective mechanisms serve as essential elements within transformative gamification platforms (Tanouri et al., 2022).

3. Theoretical Frameworks

Gamification encompasses a range of key characteristics, which can be elucidated through various theoretical frameworks, explaining social aspects, intrinsic and extrinsic motivation.

Maslow’s Hierarchy of Needs provides insights into the intrinsic motivations underlying gamified experiences, while the Self-Determination Theory describes various degrees of motivation (Ryan & Deci, 2000). Theories such as Social Comparison Theory (Festinger, 1954) and Personal Investment Theory (Maehr & Braskamp, 1986) shed light on the social dynamics within gaming contexts.

Additionally, reward-based theories, including the Expectancy Value Theory (Atkinson, 1957; Wigfield & Eccles, 2000) and Skinner's Reinforcement Theory (Skinner, 1958), offer further perspectives on the mechanisms driving gamification effectiveness (Richter et al., 2014). Lastly, Robson's MDE framework elucidates how game elements are incorporated in gamified experiences (Robson et al., 2015).

To go further into detail, the Hierarchy of Needs framework highlights the intrinsic motivations that can be activated by gamified elements, suggesting that fulfilling basic needs, such as understanding the rules of the game, can encourage users to engage more deeply as they progress toward satisfying higher-level needs, which regard graphics and visuals (Siang & Rao, 2003).

The most famous theory that explains human motivation is the Self-Determination Theory (SDT). It emphasizes the extent to which an individual's conduct is self-motivated and self-determined. SDT identifies three basic psychological requirements that, when met, improve human motivation, performance, and well-being. These requirements are autonomy, competence, and relatedness. Autonomy is the urge to be in control of one's own actions and goals. Autonomy refers to behaving with a sense of volition and having the freedom to choose one's own activities. Competence is the desire to feel capable and effective in one's actions. Competence is knowing how to do something, having the chance to use that knowledge, and experiencing a sense of mastery and accomplishment. While relatedness is the desire to have a sense of belonging and attachment to people in the same environment. In relation to gamified experiences, research has demonstrated that feelings of competence, autonomy, and relatedness are key factors in enhancing enjoyment (Przybylski et al., 2010). Games and gamified experiences are both connected to the three psychological requirements since they encourage competence via reward systems and promote relatedness through social collaboration and competitiveness.

Likewise, the Social Comparison Theory (Festinger, 1954) elucidates the social dynamics at play, where elements like leaderboards and rankings promote engagement through comparative motivation and competition, driving individuals to achieve better results in relation to their peers.

On the other hand, the Expectancy Value Theory explains how the effort to engage in gamified activities is influenced by the perceived value of the activity and the user's expectation of success, guiding the design of tasks that are both achievable and rewarding. Using rewards can increase a user's perception of control over their own goals, thereby increasing their emotional investment in the gamified experience (McNamara, 2010).

The effectiveness of incentives on human behavior is explained in Skinner's Reinforcement Theory. This theory focuses on strengthening the desired outcome in gamification, engagement, or participation through a series of reinforcements or incentives. Thus, it suggests that positive reinforcement through gamified rewards can significantly enhance user engagement and behavior modification.

Together, these theories provide a comprehensive understanding of the motivational, social, and rewarding mechanisms that underpin the effectiveness of gamification strategies.

A more recent theory focuses on the game design of gamification strategies. Gamification incorporates game elements into non-game contexts. Robson et al.'s MDE framework (2015) extends traditional gaming components to elucidate the principles of a gamified experience, specifically focusing on mechanics, dynamics, and emotions. The interrelationships among these principles are illustrated in Figure 1.

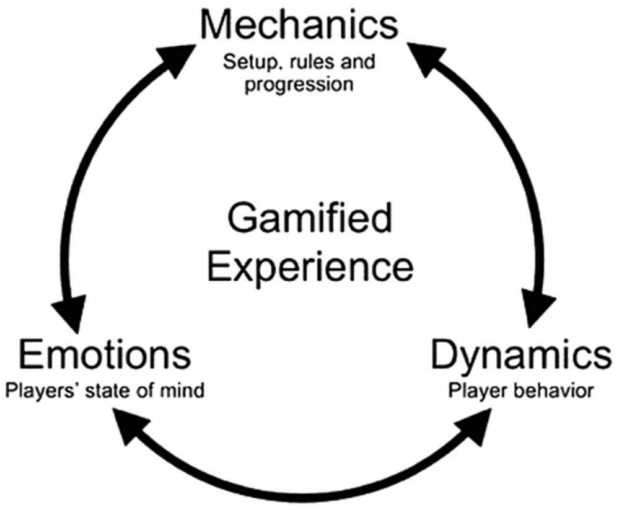

Figure 1: MDE Framework (Robson et al., 2015, p. 416).

Mechanics involve the structural elements designed by creators to define the gamified environment. This includes specifying the goals, rules, setting, interactions, and boundaries that remain constant throughout the player's engagement. This principle can be characterized by three distinct types: setup mechanics, which establish the initial conditions and player configurations; rule mechanics, which delineate what actions are permissible and under what constraints; and progression mechanics, which structure the ongoing engagement through incentives like levels and rewards, thereby fostering a continuous motivational pull for participants.

Dynamics emerge as players interact within the boundaries set by the mechanics. This principle encapsulates the live, evolving interactions and strategies that manifest during gameplay. Dynamics are not pre-scripted; rather, they develop spontaneously as players engage with the system and with each other. This principle is crucial because it introduces variability and complexity into the gamified experience. For instance, dynamics might include cooperation, competition, negotiation, and innovation as players strategize to meet game objectives or react to the actions of others. The presence of dynamics highlights the unpredictability and the organic evolution of player behavior, which can lead to both intended and unintended outcomes, thereby making the gamification experience more engaging and less predictable.

The emotional responses elicited by engagement with gamification form the third pillar of the MDE framework. Emotions are critical because they directly influence the player's motivation and satisfaction, impacting their overall engagement and the efficacy of the gamified application. These emotional reactions are induced by both the mechanics and dynamics of the game; they can range from joy and satisfaction to frustration and disappointment. Emotions in gamification should ideally be positive, enhancing enjoyment and fostering a deeper emotional connection to the experience. However, they can also include a mix of feelings that reflect the real challenges and stakes involved in the game, such as the tension of competition or the thrill of overcoming difficult obstacles. Effective gamification designs carefully balance these emotional aspects to maintain player interest and commitment, thereby ensuring that the experience is compelling enough to motivate continued participation and achieve desired behavioral outcomes.

Together, these three principles of Mechanics, Dynamics, and Emotions create a complex and interactive environment in gamified systems. Understanding their interplay is essential for designers to craft experiences that not only engage users but also drive them towards achieving specific goals, making the MDE framework a critical lens through which to view and evaluate gamification strategies.

4. Gamification Strategies in Cultural Heritage Sites

The integration of gamification into cultural heritage sites is a growing field aimed at enhancing visitor engagement and educational outcomes. Cultural heritage attractions are known for their ability to educate visitors in a more participatory way and to promote eagerness to learn and cultural awareness (Elwick, 2013). That makes cultural sites one of the most attractive sectors to employ gamification strategies. Indeed, the interactive and engaging nature of gamification aligns well with the educational goals and visitor engagement objectives of cultural heritage sites. Gamification in education and learning refers to the use of new game elements to tackle the learning difficulties of a traditional scenario (Kim et al., 2018).

Serious Games (SG), which are used for learning and education, are becoming increasingly popular. A serious game is defined as "a digital game created with the intention to entertain and to achieve at least one additional goal (e.g., learning or health)" (Dörner, 2016) or also as "the use of complete games for non-entertainment purposes" (Deterding et al., 2011). A serious game's major objective is to assist the player in achieving a learning goal, while fostering enjoyment (Anastasiadis et al., 2018). Recent research has observed the emergence of serious games aimed at enhancing cultural heritage engagement. These games utilize gameplay to facilitate the learning and teaching of historical knowledge, as well as to boost tourism in museums (Ćosović & Brkić, 2019). Most games focused on architectural and cultural heritage not only provide immersive, realistic recreations of locations that allow users to appreciate and learn about the artistic and architectural merits of these sites, but they also serve as compelling tools that encourage physical visits, enhancing the real-world experience (Mortara & Catalano, 2018).

Anderson et al. (2010) divide the most relevant case studies of serious games in cultural heritage into three categories: virtual museums, commercial historical

games, and reconstruction of sites. The first category refers to the use of VR to represent interactive virtual museums. The second category comprises all commercial historical games which show genuine historical events, such as wars and battles, and allow players to participate. Although these games were designed for enjoyment, their historical accuracy makes them suitable for educational purposes (Burton, 2005). The last category uses a mix of AR technology and gamification strategies in cultural heritage by reconstructing historical sites. By employing virtual visualizations and reconstructions of ancient sites, organizations can enhance the quality of the visitor experience. This approach allows visitors to actively learn through observation, engaging with history in a dynamic and interactive manner. All categories have a shared objective: to make learning enjoyable.

A notable instance of a Serious Game applied to cultural heritage is "The Stolen Painting," which utilizes immersive gaming technology. This game incorporates modern tools such as linked open data, digital storytelling, user personas, and UX evaluation to enhance and tailor the gaming experience. By merging educational content with entertainment, the game transforms the acquisition of knowledge into a fun and engaging activity. It has been observed that this game not only fosters a motivation to learn but also sparks a broader interest in art history and cultural heritage. Such serious games hold the promise of introducing innovative educational approaches to cultural heritage, potentially altering how participants engage with and understand art at a more profound level (Konstantakis et al., 2019).

Gamification has increasingly been explored as a means to both motivate and educate users within the context of cultural experiences. The majority of literature on this subject highlights how these strategies not only engage but also deepen users' understanding of cultural content.

A notable example of gamification applied to cultural heritage is the work of Fakhour, Azough, and Kaghat (2020), who developed an augmented reality scavenger hunt to enhance visitor engagement at cultural heritage sites. This innovative approach aims to enrich the exploration experience by integrating interactive elements that stimulate both participation and learning. Similarly, Kotsopoulos et al. (2019) have contributed to this field by focusing on the

development of applications that amalgamate gamification with cultural heritage education. Their projects seek to make learning about culture both informative and enjoyable, utilizing game mechanics to facilitate deeper engagement with the material.

Cesaria and colleagues (2020) have specifically targeted the educational sector, employing gamification techniques to engage primary school students with cultural heritage. They designed a game combining manual activities with visual information reported on a screen. Their initiatives are designed to make cultural education more interactive and immersive, thereby increasing student interest and retention of information.

In the urban context, Prandi et al. (2019) designed a mobile application enriched with gamification elements aimed at enhancing the cultural experiences of city dwellers and tourists alike. This app leverages gamification to make exploration of urban cultural sites more engaging and informative.

López-Gonzalez (2016) utilized a gamification approach in a crowdsourcing context to involve users in the collection of cultural heritage data. By gamifying the data collection process, López-Gonzalez managed to boost user participation and gather substantial cultural insights from a broad audience.

Additionally, Papathanasiou-Zuhrt, Weiss-Ibanez, and Di Russo (2017) designed a heritage game that significantly improves the user experience in historical settings. Their game specifically aims to make learning about the history of the Medieval City of Rhodes entertaining and interactive, thereby increasing visitor engagement and knowledge retention. It achieves this by engaging non-captive audiences with heritage values through an entertaining and participatory format, which allows an unlimited number of users to access and personalize key media information based on their individual preferences and interests. This customization transforms their experiences into a playful marketing tool.

Another interesting example of AR gamification was introduced at an archaeological site by Varinlioglu and Halici. This mobile AR game consisted of a treasure hunt with incorporated game elements such as a collection of artifacts, trivia questions, storytelling, and virtual points. The objective of the game was to

incentivize visitors to explore the archeological site while enhancing their knowledge (Varinlioglu & Halici, 2019).

Serious games have also been explored for underwater archeological sites such as submerged cities by catastrophic incidents or ancient sunk ships (Čejka et al., 2020). This mobile game consists of an AR guide for divers to present ancient buildings in the city of Baiae, located in Italy near Naples. This gamification strategy not only simplifies access to locations that are otherwise difficult to visit but also enriches the visitor experience by presenting historical information in an immersive and captivating manner.

The use of serious games and gamification at cultural heritage sites has various advantages, including improving the visiting experience and broadening the appeal of these destinations to a larger audience. Such innovations are especially effective at engaging younger generations, such as Generation Z and tech-savvy individuals, who frequently prefer digital and interactive content to traditional methods. This transformation not only stimulates their attention but also encourages cultural tourism, resulting in economic advantages for the countries. According to Marques et al. (2022), gamification strategies have been shown to improve visitor engagement and educational value. Gamification facilitates learning, increases knowledge retention, and makes the whole experience more fun by converting visits into interactive adventures.

Despite the potential benefits, the implementation of gamification in cultural heritage faces several challenges. These include the high costs associated with developing and maintaining digital content and the technological infrastructure required to support such applications. Additionally, there is a risk of diluting the authenticity and educational quality of cultural content in an effort to make activities engaging and fun (Varinlioglu & Halici, 2019).

While traditional forms of cultural heritage such as GLAM (galleries, libraries, archives, and museums) continue to dominate the application of gamification, there is a growing interest in using these strategies for intangible cultural heritage. Intangible cultural heritage is the sum of knowledge, expressions, and skills that a society recognizes as part of their culture. This indicates a broadening of the scope

of gamification applications beyond physical artifacts to include practices, traditions, and other non-material cultural elements (Marques et al., 2022).

The current literature illustrates the diverse ways in which gamification can be effectively utilized to enhance cultural heritage experiences. There is a general understanding that adding gamification elements and strategies to cultural heritage experiences can significantly contribute to a deeper learning and appreciation of cultural heritage. This study will expand the current literature by focusing on two components of gamification: creative thinking and enjoyment.

C. Analyzed Constructs

1. Technology Acceptance Model: Perceived Ease of Use and Perceived Usefulness

The acceptance of new technologies by users is a pivotal factor in determining the success of their implementation. The Technology Acceptance Model (TAM), introduced by Davis in 1989, stands as a leading theoretical framework for analyzing this aspect within the field of information systems (IS). According to TAM, two principal factors drive the adoption and continued use of technologies: perceived usefulness (PU) and perceived ease of use (PEOU).

Perceived usefulness is understood as the degree to which individuals believe that using a specific system will improve their job performance (Davis, 1989). This belief is based on the premise that people are more inclined to adopt technologies they view as advantageous to their work efficiency.

On the other hand, perceived ease of use is defined as the extent to which a person believes that using a technology will not require substantial effort (Davis, 1989). This notion is based on the idea that a technology that is easier to use will more likely be adopted by users, considering that effort is a finite resource and people tend to favor solutions that minimize the need for such effort (Radner & Rothschild, 1975).

The two factors are related to each other in the sense that a technology that is easier to use is often seen as more useful. Indeed, as noted by Davis (1989), in the early phases of user acceptance, there is a strong direct effect of perceived ease of use on

behavioral intention to use (BI). As the user gains experience with the technology, perceived ease of use indirectly affects BI through perceived usefulness.

Throughout the years, TAM has been broadly applied and validated across various technological contexts, including language processing, corporate systems, and games, demonstrating its adaptability and strength in predicting technology acceptance (Hess et al., 2014). Empirical studies consistently show that TAM explains a substantial portion of the variance (40%) in usage intentions and behaviors (Venkatesh & Davis, 2000).

The theoretical basis of TAM derives from the psychological Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB), which is an extension of the former (Fishbein et al., 1980; Ajzen, 1985). In addition to these models, TAM also aligns with the Diffusion of Innovations Theory by Rogers, which examines how, why, and at what rate new ideas and technology spread (Rogers, 1995). Like TAM, Rogers' theory emphasizes the role of perceived attributes of innovations, such as relative advantage (similar to perceived usefulness) and complexity (akin to perceived ease of use), in influencing adoption decisions. This synergy between the models highlights the robustness of TAM's foundational constructs within the broader framework of technology acceptance and innovation diffusion.

2. Gamification: Creative Thinking and Enjoyment

Gamification incorporates a diverse array of elements, and to accurately assess the gamified experience, we employed Eppmann's Gameful Experience Scale, also known as GAMEX (2018). He defines a gameful experience in a non-game context as "the positive emotional and involving qualities of using a gamified application" (Eppmann, 2018, p. 100). Similarly, Domínguez et al. (2013) and Robson et al. (2015) define the concept of a gameful experience as the emotions and engagement users feel when interacting with game elements in unexpected contexts. Following the GAMEX scale, a gameful experience can be measured by six factors: enjoyment, absorption, creative thinking, activation, lack of negative affect, and dominance.

The first factor is enjoyment, which refers to the pleasure and satisfaction derived from engaging with the gamified system. Enjoyment is crucial because it directly influences the user's desire to continue interacting with the system. Enjoyable experiences are often characterized by fun, engaging challenges, and rewarding moments that motivate continuous user interaction (McGonigal, 2011). The primary goal of gamification is to evoke positive emotions in the user (Aparicio et al., 2012). Indeed, Eppmann's analysis highlights that enjoyment accounts for the largest variance in gameful experiences compared to the other factors, underscoring its significant theoretical implications (Eppmann, 2018). Given the critical role of enjoyment in assessing the effectiveness of gamification, we have therefore incorporated it as one of the two primary metrics in our analysis.

The concept of 'empowerment of creativity' in gamification was introduced by an international gamification lecturer, Yu-kai Chou (2014). This driver encourages consumers to express their individualism through creative activities. This involves experimenting with new approaches and continually reinventing systems to overcome challenges, allowing individuals to exhibit their creativity and differentiate themselves from others (Brito et al., 2018). A significant contribution of the GAMEX scale lies in its focus on the creative thinking aspect of a gameful experience, an area that prior research often overlooked. Creative thinking in a gamified environment entails the ability to think in novel ways. It is fostered by challenges that necessitate problem-solving, inventing solutions, and devising new strategies, thereby making the gamified experience more stimulating and intellectually rewarding. The explorative and imaginative dimensions of creative thinking are considered crucial by many gaming researchers, such as Korhonen et al. (2009), who emphasize its significance as one of the most important aspects of gamification.

Absorption is the state of being deeply engaged or engrossed in an activity to the extent that one loses a sense of time and external reality. In a gamified context, this means that the user is so captivated by the activity that they temporarily forget about their surroundings (Hamari et al., 2014). High levels of absorption can enhance learning and performance, as the user is fully focused on the task at hand (Ryan & Deci, 2000). A large body of research focuses on cognitive absorption, since it is a strong predictor of why users play a certain game (Lowry et al. 2013). Cognitive

absorption includes factors such as user immersion, flow, and presence. Flow is defined by Ryan as the "total absorption in an activity and the non-self-conscious enjoyment of it" (Ryan & Deci, 2000, p. 260).

Activation relates to the level of arousal and energy experienced by the user during the gamified activity. Activation can be influenced by the pace, intensity, and dynamic elements of the game, such as time constraints, competitive features, and progressive difficulty levels. A well-activated user is alert, engaged, and emotionally involved in the experience (Poels et al., 2012).

To measure the success of a gameful experience, there needs to be an absence of negative affect. Ensuring that the gamified experience does not elicit negative emotions such as frustration, boredom, or anxiety is crucial (Robson et al., 2015; Harwood & Garry, 2015). This involves designing systems that are fair, achievable, and appropriately challenging. Minimizing negative effects helps maintain a positive user experience, encouraging continued participation and interaction.

The last factor is dominance, which describes the user's feeling of control and influence over the gamified environment. When users feel dominant, they believe they can significantly impact the outcome of the game through their actions. This sense of control can be empowering and gratifying, leading to higher levels of engagement and satisfaction (Poels et al., 2012).

For the sake of this study, we concentrated on only two specific dimensions of a user's gamified experience: enjoyment and creative thinking. Enjoyment is recognized as essential for achieving a positive, gamified experience. Creative thinking, on the other hand, is a relatively underexplored dimension in existing research, yet it represents a critical aspect of the gamified experience.

3. Engagement

The construct 'engagement' was taken from a scale developed by Ozlem and Mithat (2019). This scale studies the six factors that affect the gamification process in undergraduate education.

Engagement is a multifaceted construct that captures the intensity and emotional quality of an individual's involvement in particular tasks. Skinner and Belmont

(1993) describe engagement as the passionate and emotional participation in activities, emphasizing its dynamic nature. Similarly, Russell et al. (2005) view engagement as the energy invested in various behaviors and tasks. Schaufeli, Salanova, et al. (2002) further elaborate on engagement as a sustained and positive affective-motivational state of fulfillment, characterized by three dimensions: vigor, dedication, and absorption.

Vigor is characterized by high energy, resilience, a readiness to exert effort in a specific task, an enduring capacity against fatigue, and tenacity in facing challenges. Dedication refers to a deep engagement with one's work, coupled with enthusiasm and a feeling of pride and inspiration. Absorption describes a gratifying state of deep involvement in a task, where time seems to accelerate and disengaging from the task becomes difficult.

According to research, people are more likely to remain engaged in an activity if they enjoy it or perceive it as valuable (Nakamura et al., 2003). Gamification and engagement are inherently connected because the primary goal of any game is to captivate its players. In fact, a game can be described as a system where players engage in a virtual conflict governed by rules, leading to a measurable outcome (Tekinbas & Zimmerman, 2003). Gamification is a strategy renowned for enhancing both enjoyment and engagement (Hamari et al., 2014).

In the study, the ‘engagement’ construct assesses participants' immersion and interaction during the AR tour. This construct evaluates key aspects of engagement, including whether participants focus primarily on the play elements of the AR experience, suggesting high engagement driven by the gamified components of the tour. It also examines participants' perception of time, assessing whether they feel that time is passing quickly, which indicates deep immersion in the activity. Additionally, it measures the extent of active participation, gauging how committed participants are to interacting with and responding to the AR content. These dimensions collectively provide a comprehensive view of the gamified AR tour's ability to engage users by measuring their focus, perceived time flow, and involvement.

4. Perceived Learning Effect

The ‘perceived learning effect’ construct was also taken from the scale developed by Ozlem and Mithat (2019). The scale was originally intended to measure the perceived learning effect of a gamified learning environment (GLE) and was modified to capture the perceived learning effect of the AR tour.

Gamification has been extensively researched as a strategy to increase motivation in learning and understanding concepts (Hakulinen et al., 2013; Jackson et al., 2022; Song et al., 2017; Yıldırım, 2017). Numerous studies have explored the implementation of gamification in educational settings, examining its impact on student behavior (Hanus & Fox, 2015; Rashid & Suganya, 2017).

Landers (2014) introduced the theory of gamified learning, which includes two principal components: a framework that categorizes game elements likely to improve learning and a theoretical model linking gamification efforts to learning outcomes. Landers describes gamified learning as "the use of game elements, such as action language, assessment, conflict/challenge, control, environment, game fiction, human interaction, immersion, and rules/goals, to facilitate learning and related outcomes" (p. 757). This definition is based on the framework proposed by Bedwell and colleagues (2012) concerning learning-related game attributes.

Moreover, Landers’ model suggests that gamification can influence learning through one of two mechanisms: either by improving existing instructional practices to enhance learning or by promoting behaviors or attitudes that directly improve learning outcomes. In both scenarios, the intent of gamification is to influence a behavior or attitude related to learning.

In the study, the ‘perceived learning effect’ construct assesses participants' subjective evaluations of their learning experiences during a gamified AR tour of a cultural heritage site. This construct captures the cognitive and affective components of learning by measuring several key dimensions: the enhancement of historical understanding through information about the castle's history, the effectiveness of immediate feedback in facilitating the learning process, and the tour's ability to help achieve specific learning goals. Additionally, it assesses participants' propensity to actively interact with the learning material, as well as

their attitude changes regarding the subject matter, particularly their enthusiasm for the tour's contents.

III. METHODOLOGY

A. Research Questions

This study focuses on the effects of gamification on tourists' augmented reality experience and aims to answer the following research questions:

RQ.1 Can AR-based gamification strategies enhance engagement of tourists of heritage tourism?

RQ.2 Can AR-based gamification strategies increase the perceived learning effectiveness and satisfaction of a cultural heritage tour?

B. Survey Design

The survey consisted of 29 questions. The participants were shown a scenario set in a medieval castle and were asked to imagine being part of the proposed AR journey. Then, they were asked to evaluate each statement on a 7-point Likert scale ranging from (1) "Strongly disagree" to (7) "Strongly agree." The primary objective was to take respondents on a captivating journey through time, using gamification elements to enhance their interaction with the cultural heritage site. The scenario presented to the participants was as follows:

> "Imagine the following scenario. You enter a medieval castle with rich historical significance, and you are equipped with an augmented reality (AR) headset upon entry. This headset serves as a gateway to an immersive experience, combining education, exploration, and entertainment. You can choose to go on the quest by yourself or with a group, choosing the multiplayer option. In this case, the whole group will see the same augmented reality.
>
> When you wear the AR headset, you are asked to select a historical character or avatar to embody during their visit. Each character comes with a unique story closely tied to the castle's rich history, allowing you to personalize your experience. A virtual guide appears in the AR headset, introducing you as time travelers on a quest to uncover the secrets of the castle. This quest involves solving puzzles, discovering

hidden artifacts, and completing challenges strategically placed throughout the castle.

As you explore the site, specific points of interest are marked with AR indicators. These markers guide participants to interactive zones where virtual NPCs (non-player characters) provide information, challenges, or clues related to different aspects of the castle's history.

Through successfully completing challenges or answering historical questions, you collect virtual artifacts. These artifacts contribute to your overall progress in the quest and unlock additional layers of historical insights.

During the quest, time-travel portals, marked by AR indicators, transport you to different historical periods within the castle. The AR headset adjusts the environment to showcase the castle's appearance during various eras, offering a dynamic and immersive journey through time. While you are discovering different time periods, occasional information pop-ups will provide historical context on events, architecture, and the lives of people during different eras. You are rewarded with collectible digital tokens upon successful completion of the quest.

The quest concludes with a visit to the Castle’s shop where you will be able to buy souvenirs with the tokens collected throughout the AR experience.”

This scenario includes various gamification elements: (1) Personalization. The avatar selection allows visitors to personalize their experience by selecting a historical character or avatar. (2) Storytelling. The quest introduction uses narrative features and storytelling to describe the scenario, framing the visit as a quest with a clear aim, and instilling a feeling of purpose and excitement. (3) Exploration. Interactive points of interest which guide the visitor through AR markers, encourage exploration and interaction with the cultural heritage site. (4) Achievement and Progression. Artifact collection fosters a feeling of accomplishment and progression inside the AR tour. (5) Rewards. Visitors are incentivized with collectible digital tokens, motivating them to complete the quest.

(6) Learning and Discovery. The periodic information pop-ups offer educational insights, promoting learning about historical events, architecture, and lives during different eras.

C. Sample Design and Data Collection

The current research utilized Prolific, an online survey tool, to enlist participants, who were then redirected to the survey on Qualtrics. This process garnered 207 individuals (average age = 36.62; age standard deviation = 12.00). The participants were prescreened based on several criteria: proficiency in the English language, interest in augmented and mixed reality experiences, as well as hobbies related to traveling and playing video games. All distributed questionnaires were filled out and returned, resulting in a complete data set with no need to discard any responses. The questionnaire containing the specific questions is included in the Appendix. Further demographic information about the participants, such as gender, level of education, and geographical area, is provided in Table 1.

Variables	*Categories*	*N*	*%*
Gender	Male	125	60.40%
	Female	82	39.60%
Education	High school	49	23.70%
	Bachelor's degree	115	55.60%
	Master's degree	43	20.80%
	Ph.D.	0	0.00%
Geographical area	North America	29	14.00%
	South America	15	7.20%
	Europe	131	63.30%
	Asia	12	5.80%
	Australia	20	9.70%
AR experience	None	6	2.90%
	Beginner	105	50,70%
	Intermediate	79	38.20%
	Advanced	16	7.70%
	Expert	1	0.50%

Table 1

D. Data Analysis

To address the issue of common method variance commonly associated with the use of self-reported questionnaires for measuring both dependent and independent variables, as highlighted by Podsakoff et al. (2003), this research implemented several approaches. Initially, participants were guaranteed anonymity to reduce potential biases in their responses. Subsequently, we analyzed Variance Inflation Factors (VIFs), looking specifically for values above 3.3 (Kock, 2015). Our findings demonstrated that all VIFs remained below this limit, suggesting no multicollinearity, and affirming the reliability of our predictive results.

For the statistical analysis, SPSS version 27.0 was utilized to carry out descriptive statistics and to assess the reliability of the constructs. The sample's demographic characteristics were also reviewed. In terms of the research model analysis, we used Partial Least Squares (PLS) through the SmartPLS 3.0 application. Following Hair et colleagues' (2013) suggested methodology for Structural Equation Modeling (SEM), we first validated the measurement model and then proceeded to test the structural model.

IV. FINDINGS AND RESULTS

A. Measurement Model

The assessment of the measurement model's convergent validity was rigorously conducted through the analysis of several key indicators, including factor loadings, Cronbach's alpha (α), Composite Reliability (CR), and Average Variance Extracted (AVE). The results of this comprehensive evaluation are thoroughly presented in Table 2. Each standardized factor loading exceeded the recommended threshold of 0.5, indicating robust item reliability (Hair et al., 2009). Additionally, the CR values not only met but exceeded the widely accepted benchmark of 0.7, underscoring the high reliability of the constructs. Similarly, the AVE scores exceeded the critical value of 0.5, further confirming the model's strong convergent validity in line with the guidelines provided by Hair et al. in 2013.

Construct	*Cronbach's Alpha*	*Composite Reliability*	*Average Variance Extracted (AVE)*
ENGAGE	0.658	0.794	0.581
ENJOY	0.911	0.934	0.741
CREAT	0.912	0.938	0.792
LEARNEFF	0.878	0.911	0.672
PEOU	0.812	0.887	0.725
PU	0.943	0.956	0.814
SATIS	0.893	0.925	0.756

Table 2

Moreover, to enhance the credibility and validity of these findings, Table 3 details the t-values and p-values associated with each standardized factor loading. These statistical measures provide a deeper insight into the significance and reliability of each construct within the model, allowing for a more nuanced understanding of the statistical robustness of the model's constructs. This dual-layer presentation of both the reliability metrics and their corresponding significance tests enriches the overall validation process of the measurement model, solidifying its foundational role in the broader research framework.

Factor	*Indicator*	*z-value*	*P*	*Std. Est. (lv)*
SAT	SATISFACTION_1	13.864	< .001	0.835
	SATISFACTION_2	13.498	< .001	0.919
	SATISFACTION_3	13.478	< .001	0.874
	SATISFACTION_4	15.366	< .001	0.907
PU	PU_1	15.093	< .001	1.145
	PU_2	14.020	< .001	1.114

	PU_3	16.528	< .001	1.155
	PU_4	16.966	< .001	1.173
	PU_5	16.584	< .001	1.155
PEOU	PEOU_1	10.968	< .001	0.834
	PEOU_2	14.530	< .001	0.924
	PEOU_3	10.318	< .001	0.770
GAMIF - CREATIVE	GAMCREATHINK_1	15.625	< .001	0.954
	GAMCREATHINK_2	12.699	< .001	0.835
	GAMCREATHINK_3	15.262	< .001	0.803
	GAMCREATHINK_4	16.691	< .001	0.998
GAMIF - ENJOY	ENJOYM_1	15.318	< .001	0.782
	ENJOYM_2	14.434	< .001	0.840
	ENJOYM_3	15.471	< .001	0.840
	ENJOYM_4	16.176	< .001	0.936
	ENJOYM_5	10.610	< .001	0.867
LEARNEFF	PERCLEARNEFF_1	12.071	< .001	0.712
	PERCLEARNEFF_2	12.472	< .001	0.816
	PERCLEARNEFF_3	14.058	< .001	0.901
	PERCLEARNEFF_4	11.708	< .001	0.844
	PERCLEARNEFF_5	13.238	< .001	0.922
ENGAG	ENGAG_1	3.845	< .001	0.392
	ENGAG_2	9.424	< .001	0.702
	ENGAG_3	14.768	< .001	0.958

Table 3

Following this, the study examined the discriminant validity of the constructs to verify that they are sufficiently distinct from one another. Employing the methodology advocated by Henseler et colleagues (2015), we calculated the Heterotrait-Monotrait (HTMT) ratio of correlations. This statistical technique is based on the Multitrait Multimethod Matrix and is pivotal for assessing whether constructs that are theoretically different are empirically distinct. The results, which are detailed in Table 4, showed that all HTMT ratios were below the critical threshold of 0.85. These findings not only support the discriminant validity of the measures but also reinforce the integrity of the construct distinctions within our study, ensuring that each represents a unique aspect of the research model.

SAT	*PU*	*PEOU*	*GAMIF - CREATIVE*	*GAMIF - ENJOY*	*LEARNEFF*	*ENGAG*
1.000						
0.555	1.000					
0.593	0.423	1.000				
0.730	0.533	0.430	1.000			
0.778	0.531	0.552	0.904	1.000		
0.744	0.565	0.585	0.775	0.774	1.000	
0.586	0.411	0.327	0.610	0.652	0.519	1.000

Table 4: Heterotrait-monotrait ratio

To evaluate the overall fit of the model, a variety of fit indices were utilized, such as CMIN/df, CFI, GFI, SRMR, and RMSEA. The results for these indicators are displayed in Table 5 and all fell within the accepted ranges previously established by seminal research in the field (Bentler, 1990; Hair et al., 2009; Hu & Bentler, 1998; Schumacker & Lomax, 2015; Ullman, 2001). These outcomes confirm the robustness of our model, indicating that it effectively represents the data and underlying theoretical constructs.

Fit Indices	*Recommended Value*	*Obtained Value*
CMIN/df	2-5	2.034
CFI	>.90	.937
GFI	>.90	.968
SRMR	<.08	.042
RMSEA	<.08	.063

Table 5: Fit Indices.

B. Structural Model

The study analyzes two structural equation models. Both models assess the impact of perceived ease of use (PEOU) and perceived usefulness (PU) on visitor engagement (ENGAGE), perceived learning effectiveness (LEARNEFF), and overall satisfaction (SATISF). In the first model (see Figure 2), the mediating effect of gamification's creative thinking aspect (CREAT) is examined. The second model (see Figure 3) adopts a similar framework but replaces the creative thinking construct with enjoyment (ENJOY).

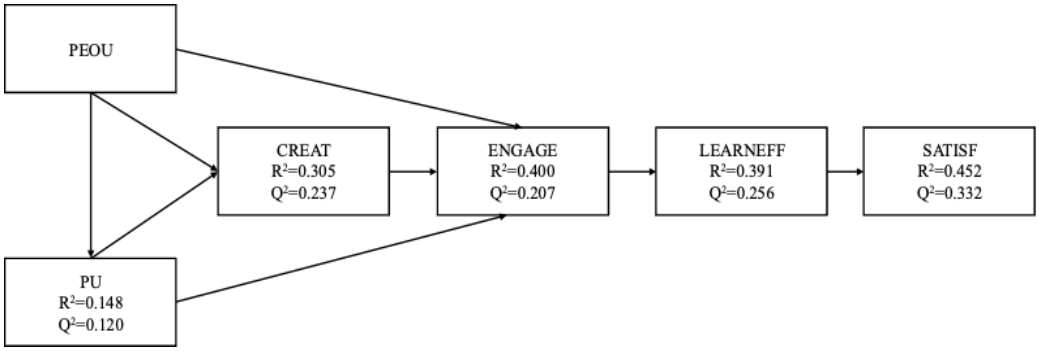

Figure 2: First Model.

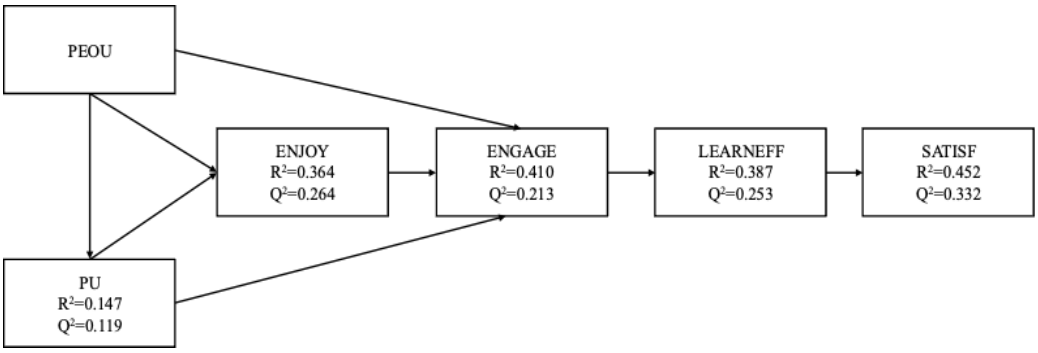

Figure 3: Second Model.

The assessment of the structural models involved several key statistical measures as suggested by Hair and colleagues (2013). This included an evaluation of R^2 values and beta coefficients along with their corresponding t-values, which were obtained through a bootstrapping technique involving 5000 resamples. Additionally, it was important to examine the predictive relevance (Q^2) and effect sizes (f^2) of the models. The predictive relevance, determined through the blindfolding method and cross-validated redundancy, measures how well the model can reconstruct empirical data using the parameters derived from Partial Least Squares (PLS) analysis. A Q^2 value above zero indicates that the model possesses predictive relevance, while a value below zero suggests a deficiency in this area. Moreover, the effect sizes, f^2, were calculated to assess the impact magnitude of the predictors, applying Cohen's (1988) thresholds of 0.02 for small, 0.15 for medium, and 0.35 for large effects. These thresholds have been determined because, although p-values signal the presence of an effect, they do not measure its intensity.

Relationships	*Beta*	*t-value*	*f 2*	*Decision*
CREAT -> ENGAGE	0.552***	10.395	0.353	Supported
ENGAGE -> LEARNEFF	0.625***	14.533	0.642	Supported
LEARNEFF -> SATIS	0.672***	16.615	0.824	Supported
PEOU -> CREAT	0.257***	4.203	0.081	Supported
PEOU -> ENGAGE	0.092	1.518	0.011	Not supported
PEOU -> PU	0.385***	6.462	0.174	Supported
PU -> CREAT	0.400***	6.250	0.196	Supported
PU -> ENGAGE	0.067	0.970	0.005	Not supported

*Notes. + p< 0.10; * p< 0.05; **p<0.01; ***p<0.001*

Table 6: Statistical Outcomes.

Relationships	*Beta*	*t-value*	*f 2*	*Decision*
ENGAGE -> LEARNEFF	0.622***	14.032	0.631	Supported
ENJOY -> ENGAGE	0.592***	9.561	0.378	Supported

LEARNEFF -> SATIS	0.672***	16.333	0.824	Supported
PEOU -> ENGAGE	0.016	0.258	0.000	Not supported
PEOU -> ENJOY	0.364***	5.178	0.178	Supported
PEOU -> PU	0.384***	6.638	0.173	Supported
PU -> ENGAGE	0.074	1.098	0.007	Not supported
PU -> ENJOY	0.361***	5.856	0.175	Supported

*Notes. + p< 0.10; * p< 0.05; **p<0.01; ***p<0.001*

Table 7: Statistical Outcomes.

In the first model, the study analyzed how gamification creativity (CREAT) predicts engagement (ENGAGE), revealing a noteworthy and positive association ($\beta = 0.552$, $p < .001$), with a moderate to substantial effect size ($f^2 = 0.353$), thereby confirming the hypothesized link. Engagement (ENGAGE) was then found to significantly impact learning effectiveness (LEARNEFF), with a strong positive effect ($\beta = 0.625$, $p < .001$) and a large effect size ($f^2 = 0.642$). Furthermore, a robust relationship between learning effectiveness (LEARNEFF) and satisfaction (SATIS) was identified ($\beta = 0.672$, $p < .001$), which was the strongest effect observed ($f^2 = 0.824$).

When considering the role of perceived ease of use (PEOU), it showed a positive influence on creative thinking (CREAT) with statistical significance ($\beta = 0.257$, $p < .001$), though the effect size was relatively modest ($f^2 = 0.081$). However, both PEOU's and PU's influence on engagement (ENGAGE) was not statistically significant, indicating an effect size that was negligible. In contrast, perceived usefulness (PU) was a significant predictor of gamification creative thinking (CREAT), with effect size indicating a moderate impact ($\beta = 0.400$, $f^2 = 0.196$, $p < .001$). Consistent with the technology acceptance model, perceived ease of use (PEOU) significantly and positively affected the perceived usefulness (PU) of the AR tour ($\beta = 0.385$, $p < 0.01$).

In the second model, the analysis was replicated by substituting creative thinking (CREAT) with enjoyment (ENJOY). Starting from TAM's variables, both perceived usefulness (PU) and perceived ease of use (PEOU) did not have a significant impact engagement (ENGAGE). However, both PU and PEOU showed significant and positive effects on enjoyment ($\beta = 0.361$, $p < 0.01$; $\beta = 0.364$, $p < 0.01$). PEOU's prediction of perceived usefulness (PU) remained significant also in this model ($\beta = 0.384$, $p < 0.01$).

Enjoyment (ENJOY) was introduced as a determinant, where it had a significant positive effect on engagement (ENGAGE), with a substantial effect size ($\beta = 0.592$, $p < .001$, $f^2 = 0.378$). Furthermore, the model examined the effect of engagement (ENGAGE) on perceived learning effectiveness (LEARNEFF), which resulted in a strong, ($f^2 = 0.631$) positive relationship ($\beta = 0.622$, $p < 0.001$). Lastly, perceived learning effectiveness (LEARNEFF) was found to have a positive and significant impact on the satisfaction (SATIS) with the AR tour, exhibiting the strongest effect ($\beta = 0.672$, $f^2 = 0.824$, $p < 0.001$).

Across the models, the R^2 values were substantial, exceeding Cohen's (1988) suggested benchmark of 0.26, indicating a strong fit for the model. The predictive relevance (Q^2) was positive for all endogenous variables, indicating the models' effectiveness at data reconstruction (Figure 2 and 3). The varying sizes of the effects, as delineated in Tables 6 and 7, were in alignment with Cohen's (1988) benchmarks, further establishing the nuances of the model's predictive power.

C. Mediation Analysis

The study conducted mediation analyses to explore the intermediary roles within several relationships: 1) The role of PU between PEOU and CREAT; 2) The influence of creative thinking (CREAT) between PEOU and engagement (ENGAGE); 3) The mediation effect of CREAT between PU and ENGAGE; 4) The impact of PU in the link between PEOU and enjoyment (ENJOY); 5) The mediation by ENJOY between PEOU and ENGAGE; 6) The intermediary role of ENJOY between PU and ENGAGE.

In the initial mediation test, it was observed that PU partially mediated the effect of PEOU on CREAT, with a significant indirect effect ($\beta = .154$, $p < .001$). The overall influence of PEOU on CREAT remained significant ($\beta = .411$, $p < .001$), even when PU was accounted for ($\beta = .257$, $p < .001$), underlining PU's partial mediation.

The second analysis showed that CREAT fully mediated the effect of PEOU on ENGAGE, with a notable indirect effect ($\beta = .142$, $p < .001$). The total influence of PEOU on ENGAGE was significant ($\beta = .344$, $p < .001$), yet turned non-significant with CREAT considered, illustrating CREAT's complete mediation role.

In the third case, CREAT fully mediated the impact of PU on ENGAGE, evident from a significant indirect effect ($\beta = .221$, $p < .001$). With CREAT as a mediator, the direct effect of PU on ENGAGE became non-significant, confirming a full mediation.

The fourth analysis indicated that PU partially mediated the relationship between PEOU and ENJOY, with a significant indirect effect ($\beta = .139$, $p < .001$) and a significant direct effect even with PU included ($\beta = .364$, $p < .001$).

The fifth mediation showed that ENJOY fully mediated the effect of PEOU on ENGAGE, with a significant indirect effect ($\beta = .216$, $p < .001$). The direct effect of PEOU on ENGAGE ceased to be significant upon including ENJOY, demonstrating full mediation.

Lastly, the analysis demonstrated that ENJOY fully mediated the relationship between PU and ENGAGE, as evidenced by a substantial indirect effect ($\beta = .214$, $p < .001$). The direct effect of PU on ENGAGE disappeared with the inclusion of ENJOY, signaling complete mediation by ENJOY.

The fully mediated effects were found in three relationships: CREAT completely mediated the influence of PEOU on ENGAGE, as well as the impact of PU on ENGAGE. Similarly, ENJOY served as a full mediator between both PEOU and ENGAGE and between PU and ENGAGE. These findings suggest that the direct effects of perceived ease of use and perceived usefulness on engagement are entirely channeled through creative thinking and enjoyment respectively.

On the other hand, partial mediation was observed in two key relationships: PU partially mediated the effects of PEOU on both CREAT and ENJOY, indicating that while perceived usefulness contributes significantly to these relationships, there are additional direct effects of perceived ease of use on creative thinking and enjoyment.

V. DISCUSSION

The study of the influence of gamification on visitor engagement and satisfaction at cultural heritage sites has provided important insights for managerial decision-making. The findings can be valuable for managers of private cultural institutions, as well as governmental entities and organizations aiming to improve the attractiveness of their historical landmarks. The study has confirmed that gamification elements, specifically creativity and enjoyment, play pivotal roles in increasing visitor engagement, learning, and satisfaction, which are critical for the success of cultural heritage sites.

Our findings reveal that merely introducing useful and easy-to-use AR technology is insufficient to increase visitor engagement in a cultural heritage setting. Nonetheless, the analysis emphasizes the need to implement gamification, which increases visitor engagement by acting through two features: tourists' creative thinking and enjoyment of the game. This suggests that managers should concentrate on creating enjoyable AR experiences that stimulate visitors' creative thinking, thereby potentially increasing the time they spend at the site and improving their overall experience.

The first mediation analysis revealed that the impact of perceived ease-of-use and usefulness on engagement is fully explained by creative thinking. This finding highlights the importance of incorporating creative tasks and activities within the gamified experience to boost visitor engagement. Consequently, cultural heritage site managers should concentrate on creating interactive experiences that encourage visitors to think creatively. This might include activities like completing quests and historical riddles, exploring through AR markers, or participating in storytelling sessions that spark visitors' imagination.

The second mediation analysis showed how the relationship between perceived ease-of-use/usefulness and visitor engagement is fully explained by the levels of enjoyment induced by gamification. This underlines the importance of making gamified experiences enjoyable to boost visitor engagement. Managers should integrate fun and entertaining features, such as competitive games, incentive systems, and rewards, to make the visitor experience more enjoyable. By focusing

on the enjoyment and creative thinking elements of gamification, managers of these sites can significantly enhance the level of visitor engagement.

Furthermore, the strong positive effect of engagement on perceived learning indicates that highly engaging experiences are crucial for facilitating effective learning outcomes of AR tours. Managers should leverage this by integrating immersive and interactive technologies, such as AR-based gamification, that bring historical narratives to life. Such technologies not only captivate visitors but also enhance their understanding and retention of historical information, thereby improving learning effectiveness. Additionally, organizations can include the educational advantages of these AR-based gamification experiences in their marketing strategies to attract tourists who are particularly interested in educational tourism or interactive learning experiences.

The robust relationship identified between the perceived learning effect and satisfaction suggests that improving the educational value of gamified experiences directly contributes to higher levels of visitor satisfaction. As a result, managers should prioritize educational content within gamification strategies in cultural organizations, ensuring that activities are not only engaging but also informative and instructive. This could involve detailed narratives, information pop-ups, avatar guides, and informative quizzes that provide deeper insights into the cultural and historical context of the site or exhibit. This finding further suggests that managers of cultural sites who wish to improve their clients' satisfaction must guarantee that gamification positively contributes to visitors' learning perceptions.

Finally, the substantial R2 values across the model indicate a strong fit, suggesting that the model is effective in explaining the variance in engagement, perceived learning, and satisfaction outcomes. The positive predictive relevance (Q2) values further confirm the model's effectiveness at data reconstruction, highlighting its robustness and reliability.

To summarize, the findings of this study provide a clear directive for managers of cultural heritage sites: by integrating a user-friendly and beneficial augmented reality technology that fosters creative thinking and enjoyment through gamification, they can significantly increase visitor engagement, learning, and satisfaction. The use of gamification may result in a more interactive and rewarding

visitor experience, ultimately having positive outcomes on the return rates of these organizations. By adopting these strategies, managers of cultural heritage sites may better satisfy the expectations of today's experience-oriented and tech-savvy tourists. The implementation of AR-based gamification strategies is likely to lead to higher tourist return rates and positive word-of-mouth, contributing to the long-term success and maintenance of cultural heritage sites.

VI. CONCLUSION

This research contributes to the growing body of research on Tourism 4.0 by demonstrating the practical applications of AR and gamification in enhancing visitor engagement and learning at cultural heritage sites. In particular, it aimed to understand whether gamification at cultural heritage sites could improve engagement and satisfaction among tourists. We did this by seeing if two gamification elements, suggested by the GAMEX scale: enjoyment and creative thinking, could mediate the relationship between the perceived usefulness and ease of use of an augmented reality experience. Moreover, we wanted to discover whether increased engagement predicted the levels of learning during the AR experience and whether these elements increased overall satisfaction.

The findings highlight that the effectiveness of gamification in enhancing visitor engagement at cultural heritage sites depends not just on making features easy to use and useful but also on how much these features can make the experience enjoyable and creatively stimulating for the visitors. This information may help drive the development and execution of more successful gamification strategies, resulting in richer, more engaging visitor experiences. We recommend that managers and entities seeking to boost visitor satisfaction focus on developing a creative and enjoyable gamification experience using AR technology. Furthermore, managers could utilize gamification strategies to significantly improve visitor learning levels and the educational value of the tour.

Future research can build on these findings to further understand the impact of gamification on cultural heritage sites. To enhance this field of study, researchers could investigate the effectiveness of gamification across various types of cultural heritage sites, such as museums, historical landmarks, and archaeological sites. This would help identify which gamification elements are most effective in specific contexts or settings. Additionally, future research could focus on the economic feasibility and return on investment (ROI) of implementing gamification strategies at cultural heritage sites. Understanding the financial implications can help in making informed decisions about investing in gamification technologies and features. Another suggestion could be to study the impact of gamification on

behavioral outcomes such as repeat visits and word-of-mouth recommendations, which would clarify visitor behavior beyond immediate satisfaction.

The limitations of our study can also serve as a guide for future research. The first limitation regards the analyzed gamification components. Our analysis focused only on two elements of gamification: enjoyment and creative thinking. While future research can study all of the elements of the GAMEX scale (enjoyment, absorption, creative thinking, activation, lack of negative affect, and dominance) to understand their collective impact on the tourist experience.

The second limitation is that the study included participants with diverse cultural backgrounds and ages. Research shows that tourists from different countries may perceive AR and gamification differently due to variations in cultural norms, values, and technological familiarity. For example, certain cultures may place a higher value on traditional forms of engagement and learning, potentially viewing AR technology as less authentic or meaningful. Thus, future studies could focus on a particular country to see if there are any differences with the perceived satisfaction and engagement from the AR experience.

Additionally, age differences can impact the ease with which participants adapt to and enjoy AR experiences, with younger individuals potentially being more comfortable and enthusiastic about new technologies compared to older participants. Future research should consider conducting age-specific analyses to understand how age influences the effectiveness of AR-based gamification.

A third limitation of the study is that it did not account for the possible negative effects of AR in both the short run and long run. In the short term, users may experience physical negative effects, particularly if they are unfamiliar with extended usage of AR devices. These symptoms might reduce the overall satisfaction of the experience, deterring future interest in the technology. Additionally, AR can lead to cognitive overload, where the amount of information overwhelms the user, reducing their ability to absorb and retain information. While, in the long term, literature underlines the possibility of AR experiences to diminish authentic engagement with cultural heritage sites. As visitors become more reliant on AR, there is a risk that they may pay less attention to the actual artifacts and environment and instead focus on the gamified experience, resulting in a superficial

understanding of the site. Furthermore, there is the potential for social isolation if AR experiences are primarily designed for individual use rather than group engagement, compromising the social aspect of cultural heritage visits. Future research should investigate these potential negative consequences in greater depth to develop strategies that maximize the benefits of AR-based gamification in cultural heritage tourism while also taking into account the associated risks.

The integration of augmented reality and gamification strategies in cultural heritage tourism represents a significant advancement in improving visitor engagement, educational outcomes, and, ultimately, satisfaction. As the tourism industry continues to evolve, embracing these technologies will be crucial in meeting the expectations of modern tourists, who seek more immersive and interactive experiences. As a result, cultural heritage site managers are urged to implement these innovative solutions to not only preserve historical sites but also generate unique and meaningful tourist experiences.

VII. APPENDIX

Satisfaction, 1-7 pt. Likert scale

Source: Chung, N., Lee, H., Kim, J. Y., & Koo, C. (2018). The role of augmented reality for experience-influenced environments: The case of cultural heritage tourism in Korea. *Journal of Travel Research*, *57*(5), 627-643.

Items:

- I would be satisfied with the quality of information provided by the AR experience.
- I would be satisfied with the system stability of AR experience.
- I would be satisfied with the visual interface design (such as graphic) of the AR experience.
- Overall, I would be satisfied with the AR experience.

Perceived Usefulness, 1-7 pt. Likert Scale

Source: Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

Items:

- By going on the AR tour, I will improve my ability to accomplish the tasks I have in mind.
- By going on the AR tour, I will save time for the tasks I have in mind.
- By going on the AR tour, I will enhance the effectiveness of the tasks I have in mind.
- The AR tour will make it easier to accomplish the tasks I have in mind.
- The AR Tour will be useful in accomplishing the tasks I have in mind.

Perceived Ease-of-Use, 1-7 pt. Likert Scale

Source: Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

Items:

- It's easy to use the AR headset.
- The AR experience could be understandable and clear.
- Using the AR headset could require minimum effort.

Gamification (Creative thinking), 1-7 pt. Likert Scale

Source: Eppmann R. et al. (2018). Gameful Experience in Gamification: Construction and Validation of a Gameful Experience Scale. *Journal of Interactive Marketing* 43, 98 – 115.

Items:

- Playing the game would spark my imagination.
- While playing the game I would feel creative.
- While playing the game I would feel that I can explore things.
- While playing the game I would feel adventurous.

Gamification (Enjoyment), 1-7 pt. Likert Scale

Source: Eppmann R. et al. (2018). Gameful Experience in Gamification: Construction and Validation of a Gameful Experience Scale. *Journal of Interactive Marketing* 43, 98 – 115.

Items:

- Playing the game would be fun.
- I would like to play the game.
- My gaming experience would be pleasurable.
- I think playing the game would be very entertaining.
- I would play this game for its own sake, not only when being asked to.

Perceived Learning Effect, 1-7 pt. Likert Scale

Source: Ozlem Baydas & Mithat Cicek (2019). The examination of the gamification process in undergraduate education: a scale development study. *Technology, Pedagogy and Education,* 28(3), 269-285.

Items:

- I would learn about the history of the Castle during the AR tour.
- It would contribute to my learning while getting immediate feedback for every question I might have during the AR tour.
- Doing the AR tour would help me achieve the learning goals.
- I feel that I would make an effort to learn during the AR tour.
- I would feel more positive towards topics regarding the Castle while doing the AR tour.

Engagement, 1-7 pt. Likert Scale

Source: Ozlem Baydas & Mithat Cicek (2019). The examination of the gamification process in undergraduate education: a scale development study. *Technology, Pedagogy and Education*, 28(3), 269-285.

Items:

- I would just focus on playing while doing the AR tour.
- Time would pass so fast while doing the AR tour.
- I would engage myself while doing the AR tour.

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