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Article

Fostering cultural heritage awareness through VR serious gaming: A study on promoting Saudi heritage among the younger generation

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Abstract: This study employs a virtual reality (VR) game to examine the role of VR gaming in learning Saudi cultural heritage. By creating 3D (Three-dimensional) virtual heritage buildings, the game immerses players in cultural scenes, fostering a lasting appreciation for art history. Objectives include making heritage information dissemination engaging, blending learning and entertainment in a 3D environment, designing a gamified setting for active learning, and igniting interest in culture, tradition, architecture, and art history. This paper further highlights the significance of serious gaming in promoting the Saudi cultural heritage among the younger generation. The research involved immersing 59 participants into a heritage building environment using a VR game and then probing their experience of the environment through a questionnaire. Results indicate positive participant experiences, increased interest in Saudi cultural heritage and appreciation for VR technology. The study demonstrates the potential of VR games to make heritage accessible and enjoyable for the younger generation, motivating further exploration and learning. Valuable resources are provided for individuals and researchers interested in using VR gaming for cultural heritage engagement.

Keywords: virtual reality; serious game; post games experience; cultural heritage; user experience; Saudi Arab

1. Introduction

Dutch culture theorist Johan Huizinga recognized play as ‘an essential element of human civilization, and its content is deeply connected with art, poetry, religion, warfare and other cultural elements (Anchor, 1978, Huizinga, 2003). Video games and virtual worlds are important to modern society, especially among individuals raised with digital media. For instance, the current generation, the digital natives, views computers as a companion that helps them get through their daily lives (Creighton, 2018). Today, an average gamer is about 40 years old and has played for about 20 years (Creighton, 2018). With an estimated market size of about USD 221 billion in 2022 and a demographically varied market with a balanced gender split, gaming is a significant global industry that other industries can tap. According to Hoffmann et al. (2014), the average young person in today’s strong gamer culture will have spent 10,000 hours gaming by the time they are 21; this highlights the significance of gaming to the younger generation. In addition to the entertainment and pleasure young people derive from gaming, they are also effective teaching tools (Gee, 2003; Mahajan et al., 2023). Most digital game-based learning apps focus on traditional subjects like biology, chemistry, or physics that profit from 3D virtual worlds’ strong visuals, utilizing the concept of serious games. Serious games are a relatively newer concept that examines virtual games for purposes other than entertainment and enjoyment

(Mortara et al., 2014; Altan et al., 2022).

Serious heritage games attempt to describe a cutting-edge strategy for integrating demanding and engaging game components into virtual heritage applications (Froschauer et al., 2012). Thus, as opposed to regular learning games, serious games broaden the subject range and address subjects not typically covered in formal education. For instance, many subjects, including therapy, medical, and military issues, have been explored in serious games over the years (Mortara et al. 2014). However, researchers have largely ignored the intersection between cultural heritage and gaming in the recent past. While researchers have explored and documented the widespread use of games for pleasure, there is limited research on the use of games to serve cultural heritage objectives, such as supporting historical learning and teaching or for enriching museum visitation (Froschauer et al., 2012; Mol et al., 2017). Games can reflect culture since they are made and played in a particular culture (Gee, 2003; Toscano, 2011). This assertion is the foundation for the current study, which examines how gamification can affect how players perceive a given culture. This is because gamification can promote cultural heritage awareness in ways that printed media or photographs may not (Froschauer et al., 2012). The development of computer graphics has made it possible for software engineers to digitize priceless artworks or reconstruct forgotten cultures. By using 3D modelling techniques, graphics, and animations to bring historic buildings to life, virtual heritage projects forge new paths for knowledge communication (Skublewska-Paszkowska et al., 2022).

With the popularity of digital gaming, there is a need to take additional steps to share the past with an interested generation, eventually leading to effective preservation initiatives. Moreover, there is a need to take measures in the present to ensure high-quality preservation of cultural heritage artefacts for future generations, failure to which the society is in danger of losing priceless cultural treasures.

This study uses VR games that aid in studying Saudi cultural and architectural heritage to explore the significance of VR gaming in learning about Saudi cultural heritage. Its lighthearted approach boosts learning motivation and interest in cultural heritage and architecture. By developing 3D virtual heritage buildings, the game immerses players in a heritage scene, piques their interest in culture, and helps them form lasting impressions of critical ideas from art history. The study thus aligns with the following objectives: to make disseminating heritage information more interesting, mixing learning and entertainment in an interactive and immersive 3D environment. Design a setting that feels like a game, encourages active learning as a byproduct of the game activity, and spurs interest in culture, tradition, architecture, and art history.

2. Literature review

The General Authority for Tourism and Antiquities in the Kingdom of Saudi Arabia has made significant progress in the preservation of culture and heritage, making the country one of the nations with a rich urban heritage that has kept up with global patterns towards its settlement, preservation, and care (Throsby & Petetskaya, 2021; Cabanela, 2023). The architectural legacy of the Kingdom has unique meanings and traits, as well as economic benefits for the state should it decide to invest in it. The Kingdom is an entire of urban historical monuments with a wide range of architectural

styles, including captivating and distinctive buildings preserved in their intricate details and aesthetic features to reflect the residents' tastes. This diversity reflects the traditional Saudi society's talents and the degree to which the early inhabitants of Saudi Arabia had conquered their surroundings and used local resources to their advantage.

The thriving urban culture of the Kingdom has led the tourist and antiquities authority, whose historic architectural legacy is in harmony with the modern, to take the initiative to safeguard this heritage in different governorates and regions of the country (Alrawaibah et al., 2014; Bagader, 2016). Two programs were commenced by the tourism authority to protect this cultural treasure, which coexists with the world's greatest civilizations. Eight programs in the first one are designed to protect heritage by halting the arbitrary demolition of urban heritage buildings; developing processes for the preservation, preservation, and development of urban heritage; compiling a list of urban architectural heritage that can be established as tourist destinations; classifying and registering National Urban Heritage; putting together a program to examine various global experiences in the field of conserving urban heritage; and hosting events (Alrawaibah et al., 2014).

The second initiative focuses on restoring and developing urban heritage sites, consisting of seven programs: the program for heritage villages, the program for enhancing historic city centres, the program for restoring and developing popular markets, the program for restoring historical structures built by King Abdulaziz's regime, and the program for restoring urban heritage in the red sea ports. The effort to protect the architectural heritage is engulfed with complexity due to the diversity of interests from the experts, their differing goals, and the variability of their philosophical and cultural backgrounds. Thus, conserving architectural heritage is multidisciplinary and necessitates a broader culture in engineering, construction, heritage, and philosophical backgrounds. This requires resolving the issue through a shared collective awareness among experts from designers and executive technicians and between the beneficiary of the affected architectural facility, an individual, a company, or the public sector of the significance of preserving heritage elements. Virtual reality unquestionably facilitates group interaction by increasing the depth of understanding of heritage architecture among the players. This is achievable through creating a scheduled virtual environment of urban fabric or restoring historical monuments. The rehabilitation, renovation, and development programs of national cultural sites gave rise to the ambitious aim to consolidate and deepen the notion of preserving the urban legacy, passing it on to subsequent generations, and encouraging investment in it. It is activating the role of sustainable history and creating plans, strategies, and legislation to maintain it, showcasing its levels, capturing its details, and researching its historical evolution.

Although the research on the application of serious gaming on cultural heritage could be more impressive, previous studies have explored its growing popularity and application in promoting cultural heritage. Anderson et al. (2010) explored using (serious) games to promote cultural heritage. The study examined the theories, techniques, and effectiveness of the tools employed by programmers. The authors studied the subject in subthemes of virtual museums, commercial historical games, prototypes and virtual demonstrators. The study highlighted the significance of virtual

museums and virtual demonstrators in enhancing the long-lasting memory of the users.

One of the significant studies in serious gaming was the creation and subsequent documentation of the 'Virtual Egyptian Temple' (Jacobson & Holden, 2007). The creation mimicked an ancient Egyptian civilization produced via a lifelike 3D replica of the ancient temple. The study underscored the significance of developing virtual reality games from a lay audience perspective, as depicted in the project that captured all of the essential characteristics of a classic New Kingdom-era Egyptian temple. The other similar but significant virtual environment gamification study entailed the creation of the Thermopylae Museum (Christopoulos et al., 2013). The project on the ancient conflict site has implemented a virtual reality exhibition. To pass historical information on the conflict, the authors employed storytelling techniques and modern video gaming concepts, which they established to be effective in passing cultural heritage information.

The development of an immersive experience on ancient history is supported by the interactive gaming achieved through C++, OpenGL, and CGI movies (Anderson et al., 2010). Further, modern games focusing on cultural heritage frequently shape museum games. An on-site exhibition already has these games built into it, or they are standalone online museums. A self-contained gallery is such an example (Fominykh et al. 2016). The project introduces the virtual 3D Environment for Learning Arts and addresses modern cultural heritage (VELA). In VELA, users who are guided by 3D avatars get heritage information by exploring European cities, stopping by galleries, museums, and artist studios, and interacting with agents or bots (Froschauer et al., 2012; Fominykh et al., 2016). Although there is no explicit comparison to their real-world counterparts, the scenes in VELA resemble genuine cities with matching exteriors and interiors. Most current projects centre on museum games seamlessly linked to contemporary social networking sites. Such games fit within the constructivist learning theory since they actively include the player in the learning experience (Goins, 2010). An example is the 'My Museum' game on Facebook. Museum is a task-scheduling game that enables numerous users to interact with and discover museum artefacts (Goins, 2010).

Players can design their exhibition area by purchasing furniture and scanned items from the Smithsonian Museum of American Arts collection. Concisely, the extant literature suggests increasing the application of virtual gaming programs to achieve the intersection of gamification and cultural heritage. Moreover, the studies imply growing interest in virtual game users. Satisfaction and immersion into the gaming environment by the users point to a significant potential that serious gaming bears in promoting the cultural heritage of a nation.

3. Methodology

The methodology employed in this research involved utilizing architectural plans obtained from the Qassim Heritage Authority. A comprehensive simulation of the Almusukaf market building was created using 3D MAX software, as shown in **Figure 1a,b**. The Unreal Engine designed the game for the Meta Oculus Quest platform. The game belonged to the category of treasure-hunting games, wherein players were given a specific time limit to uncover hidden objects using written instructions or clues.

Upon completing the game, participants were requested to fill out a questionnaire. Before engaging in the game, participants received verbal orientation to familiarize them with the gameplay mechanics.

The game was played in a typical and serene environment. Fifty-nine participants were conveniently selected to partake in the virtual heritage game. The participants' demographics comprised 31 men and 28 women, ranging in age from 20 to 40. Following their gameplay experience, participants were required to complete a questionnaire covering various subscales, including the presence scale, engagement scale, immersion scale, level of flow and control, gaming device emotion scale, judgment scale, post-game experience, adoption of technology, intrinsic motivation, and prompting awareness scale.

(a) **(b)**

Figure 1. (a) Exterior Picture for Almusukaf market; **(b)** Exterior Picture for Almusukaf market.

3.1. Participant demographics

Table 1. Respondent profile.

	Respondents demographic	**Frequency**	**Percentage (%)**
Gender	Male	31	53
	Female	28	47
Age	20–24	31	52
	25–29	15	25.42
	30–34	09	15.25
	35–40	4	6.77
Education	Secondary School	33	56
	Bachelor Degree	14	23.80
	Postgraduate Degree	12	20.33
Nationality	Saudi Arab	46	78
	Non-Saudi Arab	13	22

N = 59 respondents.

A total of fifty-nine participants took part in the virtual heritage game, representing a diverse range of demographics. These demographics provide a varied representation of participants regarding age, educational attainment, and nationality, contributing to a diverse pool of perspectives. The participants' characteristics are detailed above in **Table 1**, indicating that about 53% are male participants, about 52% are 20–24 years old, followed by 25–29 years, 25.42%, about 56 participants with education level they are a secondary school, followed by graduation, and most of them are Saudi national.

3.2. Case study: Almusukaf market, AlQaseem, Onaizah

Onaizah, situated in the Qassim region, is the second-largest governorate in the region. It holds historical significance due to its unique physical location on the Najd plateau in the middle of the Kingdom of Saudi Arabia. Bordered by dunes to the north and west and comprising sand and trees to the south, Onaizah has played a significant role since antiquity. The Almusukaf market, located in Al-Qassim City, is prominent. Constructed in 1428 AH, the market features monumental finishes and is situated close to the site of the previous ceiling market, which was demolished in 1394 AH. The market follows traditional architectural styles, with a square surrounded by mud-brick arcades covering an area of 5000 m2. It serves as a hub for popular heritage collectables, showcasing folk crafts and hosting traditional shows monthly and weekly.

3.3. Hardware

The Oculus Quest 2 is an all-in-one virtual reality headset incorporating innovative features to power the next generation of VR games and experiences. It utilizes the Oculus Insight tracking system and includes redesigned Touch controllers for improved ergonomics and extended battery life compared to its predecessor, Quest.

3.4. Software

To build the game, various software and hardware tools were employed. The critical resources utilized in this study are as follows:

3D MAX 2021: The comprehensive simulation of the Almusukaf building was conducted using 3D MAX software. **Figure 2a–d** showcases the modelling process of the building from both the inside and outside perspectives. Four traditional Saudi utensils (Al-Sameel, Baghdadi Dalla, Sahafa, and Ghadar plate) were also selected and simulated using 3D MAX (**Figures 3a, b**). The Al-Sameel vessel, for instance, was historically used to stir cattle milk and transform it into butter.

Unreal Engine: The Unreal Engine, developed by Epic Games, is a 3D computer game engine utilized to create the game for the Meta Oculus Quest platform. Written in C++, it offers high portability and supports various platforms, including desktop, mobile, console, and virtual reality.

Figure 2a–d shows how the building is modelled from the inside out.

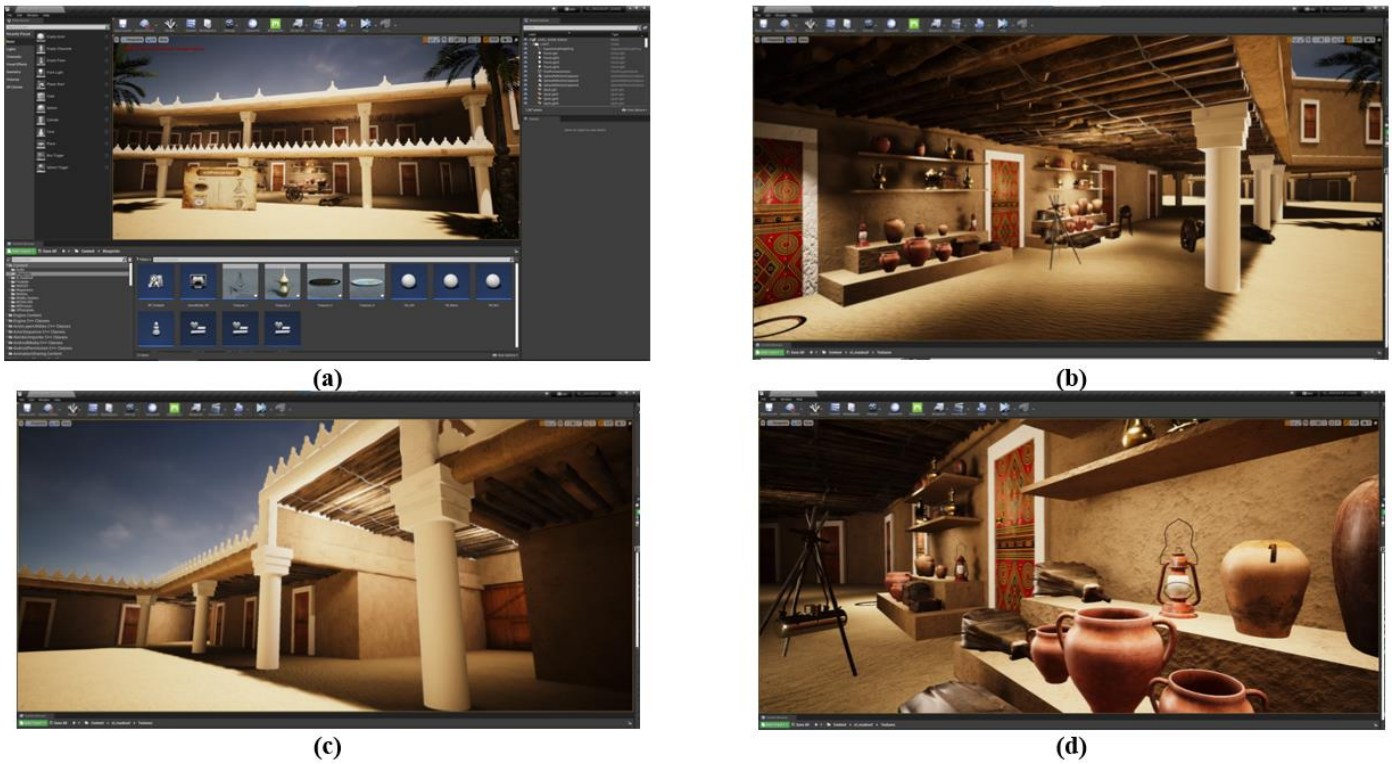

Figure 2. Building inside-out modelling (a complete simulation of the Al-musawkaf building was carried out using the 3D Max Software.

Four traditional Saudi utensils were selected to be simulated by 3d Max **Figure 3**.a From left to right (Al-Sameel, Baghdadi Dalla, Sahafa and Ghadar plate). Al-Sameel vessel used in ancient times to stir the milk of cattle to turn it into butter.

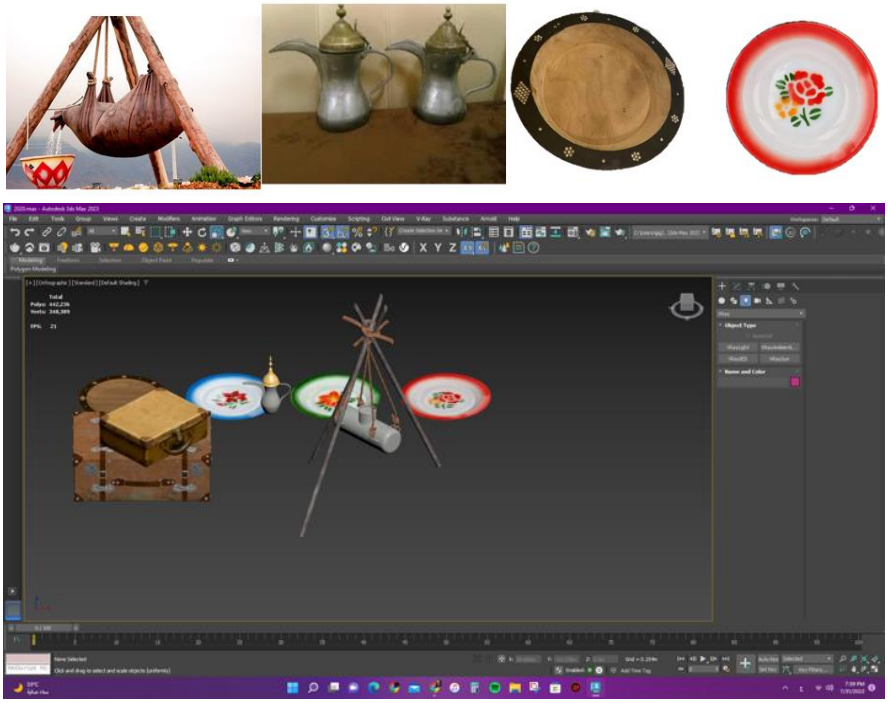

Figure 3. Real Pictures and 3D Max modeling for Traditional Saudi utensils.

3.5. User experience questionnaire

User Experience Questionnaire: After completing the game, participants were asked to fill out a questionnaire that encompassed multiple aspects, such as the game's presence scale, engagement scale, immersion scale, level of flow and control, gaming device emotion scale, judgment scale, post-game experience, adoption of technology, intrinsic motivation, and prompting awareness scale.

3.6. Game scenario

The game followed a treasure hunt format, where players were required to discover architectural features and find specific items within the given time limit. Players were given hints and tasked with searching for items by typing their local names. The objective was for the player to explore the building and locate all the utensils within 3 minutes.

4. Results and discussion

4.1. Reliability and validity

This section presents the descriptive statistics analysis of the responses of the 59 participants on the different subscales studied. **Table 2** presents findings on the reliability and validity and the factor analysis. The reliability and validity analysis was intended to stabilize the scale and demonstrate a lack of contradiction. Thus, the analysis showed that the sample could give the same results if re-applied to the same sample and test stability using Cronbach alpha coefficient. The coefficient of consistency assumes values ranging between zero and one. The proximity of the reliability coefficient value to one indicates high stability, while proximity to zero denotes instability.

Table 2. Cronbach's Alpha.

	N of items	**Cronbach's Alpha**	**Validity**
Participant presence scale	14	0.943	0.971
Participant engagement scale	5	0.863	0.929
Participant immersion scale	9	0.950	0.975
Participant level of flow and control	8	0.909	0.953
Usability of the gaming device	5	0.875	0.936
Participant's emotion scale	10	0.966	0.983
The participant judgement scale	7	0.965	0.982
Participant's post-game experience	9	0.951	0.975
Participant's adoption of technology	7	0.950	0.975
Intrinsic motivation	10	0.851	0.923
Promoting Awareness	6	0.821	0.906

From **Table 2**, all the alpha coefficients are more significant than 0.7, denoting stability and confidence for the Cronbach. Similarly, a validity score for all the items is more significant than 0.80. **Table 2** suggests a high validity. The Cronbach's Alpha was 0.943 for the participant presence scale, 0.863 for participant engagement scale,

0.950 for the Participant immersion scale, 0.909 for participant level of flow and control, 0.875 for usability of the gaming device, 0.966 for Participant's emotion scale, 0.965 for the participant judgment scale, 0.951 for Participant's post-game experience, 0.950 for Participant's adoption of technology, 0.851 for intrinsic motivation, and 0.821 for promoting awareness. Such high scores in each item demonstrate the reliability of the instrument used for the research (with a range of 82.1% and 96.6%). Such reliability is supported by high validity coefficients of between 0.906 and 0.983 (with a range of between 90.6% and 98.3%).

4.2. Factor analysis

Factor analysis is a statistical method used to find a small set of unobserved variables (also called latent variables or factors), which can account for the covariance among a more extensive set of observed variables (also called manifest variables). A factor is an unobservable variable that is assumed to influence observed variables. Factor analysis is also used to assess the reliability and validity of measurement scales. **Table 3** reveals that the component coefficient values for all items (representing the loading coefficients for each latent variable) are more significant than 0.50.

Table 3. Factor analysis for all variables.

Variables	Kaiser-Meyer-Olkin Measure of sampling adequacy	Approx Chi-Square	DF	Sig.	AVE
Participant presence scale	0.755	1248.185	91	0.000	58.350
Participant engagement scale	0.835	179.644	10	0.000	66.683
Participant immersion scale	0.743	669.870	36	0.000	71.774
Participant level of flow and control	0.822	426.862	28	0.000	62.540
Usability of the gaming device	0.800	190.553	10	0.000	67.943
Participant's emotion scale	0.829	939.077	45	0.000	77.443
The participant judgement scale	0.871	691.098	21	0.000	83.495
Participant's post-game experience	0.821	755.512	36	0.000	72.804
Participants' adoption of technology	0.778	552.757	21	0.000	77.661
Intrinsic motivation	0.733	444.077	45	0.000	51.199
Promoting awareness	0.712	173.110	15	0.000	54.047

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy, with scores of between 0.712 and 0.871, suggests a significant relationship between items for each variable at a confidence interval of 99%. Chi calculated between 173.110 and 1248.185, with DF between 10 and 91, more significant than chi tabulated, implying a test for the factor analysis for this dimension. Further, the average variance extracted for each variable is 51.1% to 83.4%, greater than 50%. These scores and coefficients strongly express and measure the latent variables for the items.

4.3. Descriptive analysis

4.3.1. Participant presence scale

The analysis of items on participant presence in **Table 4** revealed an arithmetic mean of 3.975 (SD = 0.741). The statistical score does not differ significantly from the expected mean of 4.000 at a significant level of 5%, with the calculated *T*-test value of |−0.278| (less than the tabulated value of 1.995). The coefficient of variation was similarly small at 18.65%. The analysis suggests a consensus among the respondents (81.35%) who agree with the statements. The statement 'My interactions with the virtual environment seemed natural' had the highest score (mean = 4.304). This had a positive difference from the mean (= 4) at a significant level of 5%, where the calculated *T*-test value reached |2.382| (more significant than the tabulated value of 1.995). The coefficient of variation of 24.66% was considered minor. The consensus among the respondents strongly agrees it was significant at 75.34%. The item statement 'I was able to examine the objects closely' had the lowest score with a mean of 3.406. This had a negative variation from the expected mean of 4 at a significant level of 1%, where the calculated *T*-test value reached |−4.913| (more significant than the tabulated value of 2.650). Such a coefficient of variation of 29.50% was considered significantly high. However, the consensus among the respondents was still significant at 70.50%.

Table 4. Results from the participant presence scale.

Items	Mean	Std. Deviation	CV	*T* Test	Rank
The virtual environment was responsive to my gaming actions.	4.043	1.049	25.95	0.344	7
My interactions with the virtual environment seemed natural.	4.304	1.061	24.66	2.382	1
The gaming devices, such as the screen, gamepad or keyboard, which controlled my movement in the virtual environment, seemed natural.	3.928	1.075	27.38	−0.560	10
I was able to actively survey the virtual environment using vision.	3.957	0.915	23.11	−0.395	9
I was able to closely examine the objects.	3.406	1.005	29.50	−4.913	14
I could examine objects from multiple viewpoints.	3.710	1.059	28.53	−2.274	12
I felt proficient in moving and interacting with the virtual environment at the end of the experience.	4.217	0.889	21.08	2.031	4
The visual display quality distracted me from performing assigned tasks.	4.290	0.842	19.63	2.860	2
The devices (gamepad or keyboard) which controlled my movement, distract me from performing assigned tasks	3.493	1.093	31.30	−3.855	13
I could concentrate on the assigned tasks rather than on the gaming devices such as the gamepad or keyboard	4.029	0.939	23.30	0.256	8
I correctly identified images in the virtual environment.	3.812	0.896	23.50	−1.747	11
I correctly identified sounds produced by the virtual environment.	4.101	0.957	23.34	0.880	5
Participant presence scale	**3.975**	**0.741**	**18.65**	**−0.278**	**3**

4.3.2. Engagement scale

Table 5 shows that the participant engagement scale had an arithmetic mean of 3.794 (SD = 0.741). This mean had a negative variation from the expected value of 4.000, at a significant level of 5%, with the calculated *T*-test value of |−2.306| (greater

than the tabulated value of 1.995). The coefficient of variation was 19.54%, indicating 80.46% consensuses among the agreeing respondents. The item 'I had a few distractions that impeded my involvement' had the highest mean score of 4.101. This had a positive variation from the expected mean of 4.000 at a significant level of 5%. The *T*-test value was |0.943| (less than the tabulated value of 1.995). The coefficient of variation was 21.79%, indicating consensuses among the agreeing respondents at 78.21%. The item 'there was a compelling sense as I moved inside the virtual environment' had the lowest mean of 3.507, which had a variation from the expected mean of 4 at significant levels of 1%. The calculated *T*-test was |−4.385| (greater than the tabulated value of 2.650), and the coefficient of variation was 26.61%. Thus, the consensus among the agreeing participants was 73.39%.

Table 5. Results of the participant engagement scale.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
I fully felt involved in the virtual environment experience.	3.623	1.072	29.60	−2.919	4
There was a compelling sense as I moved inside the virtual environment.	3.507	0.933	26.61	−4.385	5
I was involved in all aspects of the virtual environment.	3.841	0.760	19.78	−1.743	3
I felt involved in only a few aspects of the virtual environment.	3.899	0.926	23.75	−0.910	2
I had a few distractions that impeded my involvement.	4.101	0.894	21.79	0.943	1
Participant engagement scale	**3.794**	**0.741**	**19.54**	**−2.306**	**9**

4.3.3. Participant immersion scale

Table 6 shows responses on the participant immersion scale items, which had an arithmetic mean of 3.841 (SD = 0.826). This was lower than the expected mean of 4.000 at a significant level of 5% and a calculated *T*-test value of |−1.603| (less than the tabulated value of 1.995). This translated to a coefficient of variation of 21.50% and a 78.50% agreement on consensus. The highest scoring item was 'I felt stimulated by the virtual environment' with a mean of 4.493 (at a significant level of 1%, the calculated *T*-test value reached |3.533|, more significant than the tabulated value of 2.650). The coefficient of variation of 25.78% suggested 74.22% consensuses among the 'strongly agree' responses. The lowest score, 'I become so involved in the virtual environment that I lost track of time', had a mean score of 3.507. This had a calculated *T*-test value of |−6.607| (greater than the tabulated value of 2.650), with a coefficient of variation of 27.14%, indicating a 72.86% consensus among the neutral responses.

Table 6. Results from the participant immersion scale.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
I felt stimulated by the virtual environment.	4.493	1.158	25.78	3.533	1
I became so involved with the virtual environment that I was not aware of things happening around me.	4.014	1.036	25.81	0.116	3
I identified with the character I played in the virtual environment.	3.536	0.867	24.53	−4.441	7

Table 6. (*Continued*).

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
I became so involved in the virtual environment that it was as though I was inside the game rather than manipulating a gamepad and watching a screen.	3.536	0.833	23.55	−4.626	8
I felt the physicality of the virtual environment.	4.072	1.075	26.41	0.560	2
I got scared by something happening in the virtual environment.	3.913	0.935	23.90	−0.772	5
I became so involved in the virtual environment that I lost track of time.	3.290	0.893	27.14	−6.607	9
I got immersed in just a section of the virtual environment, and not all.	3.783	0.983	25.99	−1.837	6
I was completely immersed in the virtual environment.	3.928	0.975	24.82	−0.617	4
Participant immersion scale	**3.841**	**0.826**	**21.50**	**−1.603**	**7**

4.3.4 Participant's level of flow and control

Table 7 indicated that the 'participants' level of flow and control' items had an arithmetic mean score of 3.629 (SD = 0.780. This negatively variated from the expected mean of 4 at a significant level of 1%, a calculated *T*-test of |−3.955| (greater than the tabulated value of 2.650). The participants, therefore, had a 78.50% 'agree' consensus. The item 'I want to share the nice experience of the game with others' had a higher score (4.101) than the mean (calculated *T*-test value of |0.817|, and less than the tabulated value of 1.995). The majority of respondents scored 'agree' at 74.86%. The lowest scoring item was 'I felt in control of my actions as I played the game', with a mean score of 3.203. This translated to a calculated *T*-test value of |−6.870|, greater than the tabulated value 2.650). It negatively variated from the expected mean of 4. With a 30.09% coefficient of variation, there was a relatively lower 'neutral' consensus at 69.91%.

Table 7. Results for participant level of flow and control.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
I felt in control of my actions as I played the game.	3.203	0.964	30.09	−6.870	8
I knew what to do in every stage of the game.	3.551	0.932	26.25	−4.004	5
I thought time flew faster as I played the game.	3.275	1.069	32.65	−5.629	7
I lost sense of time as I played the game.	3.420	1.020	29.84	−4.719	6
I was never worried about what people around me thought as long as I played the game.	3.812	0.959	25.16	−1.632	3
I felt a very exciting moment as I played the game.	3.986	0.915	22.97	−0.132	2
I felt a great sense of well-being as I played the game.	3.681	1.078	29.28	−2.457	4
I feel I want to share the pleasant experience of the game with others.	4.101	1.031	25.14	0.817	1
Participant level of flow and control	**3.629**	**0.780**	**21.50**	**−3.955**	**11**

4.3.5. Descriptive analysis for usability of the gaming device

From the analysis **Table 8**, the items on the 'usability of the gaming device' had a mean score of 4.038 (SD = 0.733). The mean score had insignificant variation (at a 5% significance level), a calculated *T*-test of |−0.427| (less than the tabulated value of 1.995), and 81.85% consensus on 'agree' responses. The highest scoring item, 'I had good interactions and control of the device,' had an item mean of 4.594 (significance level of 1%) calculated *T*-test value of |8.555| (greater than the tabulated value of 2.650), and 87.44% concurrence with the 'strongly agree' scale. The item 'Overall, the device was easy and comfortable to use' had the lowest score of 3.841 (relatively closer to the mean of 4) at a significant level of 5%, a calculated *T*-test value of |−1.419| (less than tabulated value 1.995), and a 75.70% consensus among the 'agree' responses.

Table 8. Results on the usability of the gaming device.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
The device components, such as the Oculus headset, gamepad, and keyboard were easy to use.	3.942	0.983	24.95	−0.490	2
I had good interactions and control of the device components, such as the Oculus headset, gamepad, and keyboard.	4.594	0.577	12.56	8.555	1
I felt great consistency between the device components control and the output on the virtual environment.	3.899	0.972	24.94	−0.867	4
I found a few components of the device not easy to use as I played the game.	3.913	0.951	24.30	−0.760	3
Overall, the device was easy and comfortable to use.	3.841	0.933	24.30	−1.419	5
Usability of the gaming device	**4.038**	**0.733**	**18.15**	**0.427**	**2**

4.3.6. Participant's emotion scale

Table 9 shows that the 'participant's emotion scale' items had a mean score of 3.919 (SD = 0.895) at 5% significance level 5, calculated *T*-test value of |−0.753| (less than tabulated value 1.995). It had a coefficient of variation of 22.85%, indicating a 77.15% concurrence with 'agree'. Participants considered the item 'I enjoyed being in this virtual environment' the most important, with a mean of 4.362 (5% significance level, calculated *T*-test value of |2.588|, more significant than the tabulated value 1.995). The participants had a 'strongly agree' consensus at 73.34%. The item 'I was worried about the difficult gaming instructions' was given less emphasis at a mean of 3.072, which was significantly lower than the expected mean of 4 at a significance level of 1%, calculated *T*-test value of |−8.159| (greater than tabulated value 2.650), and a lower consensus of 69.27% on the neutral respondents.

Table 9. Participant's emotion scale.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
I enjoyed being in this virtual environment.	4.362	1.163	26.66	2.588	1
I felt scared while in the virtual environment.	3.812	1.004	26.34	−1.559	9
I could stay in the virtual environment for hours without getting bored.	4.188	1.075	25.66	1.456	2
I enjoyed the experience so much that I feel energized.	3.884	0.948	24.40	−1.016	6

Table 9. (*Continued*).

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
I was worried about the difficult gaming instructions.	3.072	0.944	30.73	−8.159	10
I wanted some distraction in order to manage my anxiety while playing the game.	3.841	0.868	22.60	−1.525	8
I found my mind wandering while I was in the virtual environment.	4.116	1.078	26.20	0.893	4
I felt bored while interacting with the device components.	3.870	0.969	25.04	−1.118	7
I felt carried away as I enjoyed the challenge of learning the virtual reality interaction devices (Oculus headset, gamepad, and/or keyboard).	3.913	0.981	25.08	−0.736	5
The images in the virtual reality game made me nervous.	4.130	1.149	27.83	0.943	3
Participant's emotion scale	**3.919**	**0.895**	**22.85**	**−0.753**	**6**

4.3.7. Participant judgment scale

Table 10 shows the mean score for all the items on the 'the participant judgment scale is 3.965 (SD = 0.970), slightly varying from the expected mean of 4 at a 5% significance level, a calculated *T*-test of |−0.301| (less than tabulated value 1.995), and a 75.53% 'agree' response consensus. Participants gave more emphasis to the item 'the virtual environment was friendly' (mean 4.333, calculated *T*-test value of |2.596| [greater than tabulated value 1.995], and a 75.39% consensus for the 'strongly agree' scale). The list emphasized the item 'the virtual environment was beautiful' (mean = 3.609; calculated *T*-test value reached |−7.758| [greater than tabulated value 2.650], and relatively lower consensus of 67.34% for 'agree' responses).

Table 10. Results for the participant judgment scale.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
The virtual environment appears practicable.	4.058	1.083	26.69	0.445	2
The virtual environment is clear.	4.029	1.029	25.53	0.234	4
The virtual environment is manageable.	3.884	1.119	28.80	−0.861	5
The virtual environment appeared to be the original.	3.797	0.964	25.38	−1.749	6
The virtual environment was exciting.	4.043	1.021	25.25	0.354	3
The virtual environment was friendly.	4.333	1.066	24.61	2.596	1
The virtual environment was beautiful.	3.609	1.178	32.66	−2.758	7
The participant judgment scale	**3.965**	**0.970**	**24.47**	**−0.301**	**4**

4.3.8. Participant's post-game experience

The analyzed data in **Table 11** shows a mean = 3.752 (SD = 0.902, 5% significance level, calculated *T*-test value of |−2.282| (greater than tabulated value 1.995), significantly varying from the expected mean of 4. With a smaller coefficient of variation of 24.05%, the consensus on the 'agree' scale was 75.95%. The highest scoring statement, 'I sweat more during my interaction with the virtual environment', had a mean = 4.087, which does not differ significantly from the expected mean of 4 (significance level of 5%, calculated *T*-test value of |0.660|, less than tabulated value

1.995, and a 73.22% consensus among the agree responses. The least scoring item, 'I suffered from eyestrain during my interaction with the virtual environment,' had a mean of 3.159, significantly and negatively deviating from the expected mean of 4 (at a 1% significance level, calculated *T*-test value of |−6.728| (greater than tabulated value 2.650), and a significant coefficient of variation of 32.85%). The item had a lower 'neutral' scale consensus among the respondents.

Table 11. Results of participant's post-game experience.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
I suffered from fatigue during/or after my interaction with the virtual environment.	3.739	0.965	25.80	−2.246	6
I suffered from headaches during/my interaction with the virtual environment.	3.899	0.957	24.55	−0.880	3
I suffered from eyestrain during my interaction with the virtual environment.	3.159	1.038	32.85	−6.728	9
I felt an increase in my salivation during my interaction with the virtual environment.	3.594	1.229	34.18	−2.744	8
I sweat more during my interaction with the virtual environment.	4.087	1.095	26.78	0.660	1
I suffered from nausea during/or after my interaction with the virtual environment.	3.783	1.041	27.53	−1.734	5
I suffered from 'fullness of the head' during my interaction with the virtual environment.	3.942	1.211	30.73	−0.398	2
I suffered from dizziness during my interaction with the virtual environment.	3.696	0.975	26.38	−2.594	7
I suffered from vertigo during my interaction with the virtual environment.	3.870	1.042	26.93	−1.040	4
Participant's post-game experience	**3.752**	**0.902**	**24.05**	**−2.282**	**10**

4.3.9. Participant's adoption of technology

Table 12 shows the items on the 'participants' adoption of technology' sought to understand their willingness to integrate technology with heritage. The items had a mean score of 3.812 (SD = 0.886), depicting a variation from the expected mean of 4 (at a significance level of 5%, calculated *T*-test value of |−1.766| [less than tabulated value 1.995]). With a coefficient of variation of 23.25%, the responses had a 76.75% consensus on the 'agree' scale. Participant scores were higher for the item 'I possess the knowhow to operate/interact with the gaming devices (Oculus headset, gamepad, and keyboard)' (mean 4.188 at a significant level of 5 from the expected mean of 4, calculated *T*-test value of |1.420|, less than the tabulated value of 1.995, and a 73.69% 'consensus' on the agree responses. Participant scores were lowest for the item 'I consider the use of the interaction devices (Oculus headset, gamepad, and keyboard) not good for me' (mean 3.420, which differs negatively from the expected mean four at a significant level of 1%, calculated *T*-test value of |−4.787| (greater than tabulated value 2.650), and a coefficient of variation of 29.41%. There was, therefore, a 70.59% consensus among the 'agree' responses.

Table 12. Results for the Participant's adoption of technology.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
It would be easy for me to become skillful at using the virtual environment.	3.957	1.021	25.80	−0.354	2
Learning to operate the virtual environment would be easy for me.	3.884	1.008	25.95	−0.956	3
I consider the use of interaction devices (Oculus headset, gamepad, and/or keyboard) not good for me.	3.420	1.006	29.41	−4.787	7
The interaction devices (Oculus headset, gamepad, and/or keyboard) would make work more interesting.	3.667	1.120	30.55	−2.472	6
I like the new technology that the interaction devices (Oculus headset, gamepad, and/or keyboard) adopt.	3.884	0.850	21.87	−1.134	4
I possess the knowhow to operate/interact with gaming devices (Oculus headset, gamepad, and keyboard).	4.188	1.102	26.31	1.420	1
The interaction devices (Oculus headset, gamepad, and keyboard) are not compatible with other technologies I use.	3.681	0.947	25.73	−2.797	5
Participant's adoption of technology	**3.812**	**0.886**	**23.25**	**−1.766**	**8**

4.3.10. Descriptive analysis for intrinsic motivation

Table 13 indicated that the Intrinsic motivation dimension had a significant mean of 4.145 (SD = 0.434), calculated *T*-test value |2.776| (greater than the tabulated value of 2.650). It had a significantly small coefficient of variation of 10.46%, which shows a large consensus of 89.54% among agreed responses. The item 'I think doing this activity could help me to improve my knowledge of cultural and architectural heritage' had the most significant item mean of 4.478 (which differs positively from the expected mean of 4 at a significant level of 1% and a calculated *T*-test value of |5.231| (greater than tabulated value 2.650). It had a coefficient of variation of 16.96% and 83.04% consensuses among the strongly agreed responses. The last item, 'I put much effort into this', had a mean of 3.971 (which slightly variated (negatively) from the expected mean of 4 at a significant level of 5%, calculated *T*-test value of |−0.314| (less than the tabulated value of 1.995), and 80.70% 'agree' consensus.

Table 13. Results for the intrinsic motivation.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
This activity was fun to do.	4.072	0.551	13.53	1.093	7
I would describe this activity as very interesting.	4.319	0.653	15.12	4.057	2
I thought this activity was quite enjoyable.	4.014	0.469	11.69	0.256	9
I think I am pretty good at this activity.	4.087	0.762	18.64	0.948	6
After working on this activity for a while, I felt pretty competent.	4.145	0.550	13.26	2.190	4
I am satisfied with my Performance on this task.	4.174	0.568	13.60	2.545	3
I put a lot of effort into this.	3.971	0.766	19.30	-0.314	10
It was vital for me to do well at this task.	4.029	0.618	15.33	0.390	8
I believe this activity could be of some value to me in heritage learning.	4.101	0.519	12.64	1.625	5
I think doing this activity could help me to improve my knowledge of cultural and architectural heritage.	4.478	0.759	16.96	5.231	1
Intrinsic motivation	**4.145**	**0.434**	**10.46**	**2.776**	**1**

4.3.11. Descriptive analysis for promoting awareness

Table 14 shows the 'Promoting Awareness' dimension items had a strong mean of 3.923 (SD = 0.567), which had limited variation from the expected mean of 4.000 at a significant level of 5%, calculated *T*-test value of |−1.132| (less than tabulated value 1.995), and a coefficient of variation of 14.46% (implying 85.54% consensus for the 'agree' responses). The item 'I learned new information that I did not know about the traditional Saudi architecture' with a mean of 4.319 (which positively variated from the expected mean of 4 at a significant level of 1%, calculated *T*-test value of |4.204| (greater than the tabulated value 2.650), and coefficient of variation was 14.59% had the largest significance to the participants. Therefore, 85.41% agreed on the 'strongly agree' scale. The item 'my information about Saudi heritage and culture has been enhanced' had the lowest mean at 3.768, which variated negatively from the expected mean of 4 at a significant level of 5% and a calculated *T*-test value of |−2.442| (greater than tabulated value 1.995). With a coefficient of variation of 20.93%, there was a 79.07% consensus among the 'agree' responses.

Table 14. Results on promoting awareness.

Items	Mean	Std. Deviation	CV	*T*-Test	Rank
I feel that my information about Saudi heritage and culture has increased.	3.884	0.697	17.96	−1.381	3
I learned new information that I did not know about traditional Saudi architecture.	4.319	0.630	14.59	4.204	1
I learned new information that I did not know about the names and shapes of traditional items and utensils.	3.797	0.933	24.56	−1.807	4
My information about Saudi heritage and culture has been enhanced.	3.768	0.789	20.93	−2.442	6
The game experience did not add to any knowledge I had.	3.797	0.850	22.39	−1.982	5
Awareness of the Saudi architectural and cultural heritage can be increased through virtual reality games.	3.971	0.747	18.81	−0.322	2
Promoting Awareness	**3.923**	**0.567**	**14.46**	**−1.132**	**5**

4.4. Discussion

Fifty-nine participants who were conveniently selected participated in the virtual heritage game. The perception of their VR game environment was assessed on different sub-scales. The sense of presence in virtual gaming is a determining factor in evaluating the effectiveness of the virtual game in achieving its intended purpose (Christopoulos et al., 2013). Results from earlier studies on the experience of presence, such as those conducted by Anderson et al. (2010) and Jacobson and Holden (2007), suggested that strategies based on virtual environments promote participants' sense of being present, learning motivation and attachment to cultural heritage. The presence scale significantly highlights the participants' ability to perceive items from diverse perspectives (Christopoulos et al., 2013), the impression of being able to move and interact freely in the virtual environment, and the high sense of the environment in the virtual reality activities.

The mean score for the presence scale is significantly high at 3.975. However, values below the mean also provide important information regarding the participants' perceptions. While the past studies were oriented on virtual reality environments with

head-mounted displays, the subscale presence has been studied in virtual environments to investigate the objectivity perceived by the viewer, the sensation of presence or the subjective assessment of being in a particular place induced by the feeling of immersion (Froschauer et al., 2012; Altassan, 2023). Similarly, the current study has envisaged the perception of movement naturalness that arises with head-mounted display gadgets, as movements occur more naturally by moving and tilting the head.

The engagement scale reveal that the participants believed that the visual elements of the virtual world involved them, with an arithmetic mean of 3.794 and a standard deviation of 0.741. Concisely, the current study corroborates with earlier research (Goins, 2010) that when organizing active learning in virtual environments for the teaching of landscape design and heritage, it is essential to construct a believable revisualization environment that concentrates the participants' attention on the work at hand rather than the realism of the representation.

In the immersion subscale, studies examine the effects of immersive in the 3D virtual environment in the Serious Games Approach and 3D modelling techniques and their advantages for investigation and research-based learning (Alfahad et al., 2022). An earlier study by Carbonell-Carrera et al. (2021) concurs with a completely immersive experience in an effectively designed 3D virtualization model. The subscale on flow and control emphasizes that when users interact with a virtual world, they experience a positive psychological state of feeling in control, enjoyment, and joy (Froschauer et al., 2012). This subscale had eleven components, yielding a relatively lower mean score of 3.629 and standard Deviation (0.780). The findings broadly suggest that the participants believed they were in complete control of the scenario, were having fun, and could fully regulate their behaviours in the virtual world (Fominykh et al. 2016). Concisely, earlier studies emphasized the significance of flow and control of virtual reality in the participants' environment.

This study alludes to the findings that the usability of the gaming devices, including the head-mounted devices and the input and display devices, improves the profound gaming experiences of the participants (Froschauer et al., 2012). The study, however, recognizes that more items would be required for the usability subscale of the questionnaire on user experience in immersive virtual environments to perform a more thorough measurement of usability in terms of effectiveness, efficiency, and user satisfaction.

The emotion subscale represents the participants' emotions as they immersed themselves in the virtual gaming environment. The subscale consisted of 15 items, with a mean score of (3.919) and standard Deviation (0.895). A positive user reaction in the virtual world is shown by receiving low ratings on these items. As reported in previous studies, effectively developed 3D virtual games score low on tenets of the virtual gaming environment, such as the feeling of tension and anxiousness (Christopoulos et al., 2013; Khali et al., 2013). This suggests that the majority of the participants in the current had unfavourable experiences with their emotions while immersed in the virtual environment.

The scores suggest that the participants consider 3D visualization of the virtual environment as a practical, understandable, manageable, original, inspiring, and even thrilling learning environment, a perspective reflecting earlier findings by Carbonell-Carrera et al. (2021). However, a few aspects of the responses regarded the judgement

scale as more aligned with the amateur than the professional realm. Prior studies primarily emphasized the necessity to quantify the virtual environment's effect on user health regarding the experiential consequence subscale (Froschauer et al., 2012; Carbonell-Carrera et al., 2021). The effects of using virtual reality for severe gaming and issues like motion sickness are frequently researched in education (Carbonell-Carrera et al., 2021). Issues such as headache, weariness, increased sweating, eyestrain, nausea, dizziness, or vertigo have been experienced in previous studies (Froschauer et al., 2012; Carbonell-Carrera et al., 2021). A low score for this subscale suggests fewer issues of negative post-game experiences. However, the study revealed a relatively high score with an arithmetic mean of 3.752 and a standard deviation of 0.902. This implies the participants reported negative issues post-game, which may need to be addressed in virtual reality game development.

Adoption of technology importantly demonstrates the level to which participants appreciated the application of technology in accessing their virtual environment. With a mean score of 3.812 and a standard deviation of 0.886, this study suggests that the participants were willing to learn how to operate the virtual environment. As already revealed in previous research, friendly interaction with gaming devices (Oculus headset, gamepad, and keyboard) improves the participants' desire to adopt the technology (Jacobson and Holden, 2007). Concisely, understanding the capabilities of gadgets such as head-mounted displays and external tracking sensors in serious gaming improves the tendency to adopt the technology. The current study findings, with a high arithmetic mean of 4.145 and standard Deviation (0.434), thus demonstrated motivation with the virtual reality and the gaming engine. Such learning environments engage participants in severe gaming environments and motivate them on the one hand.

This subscale sought to understand if the game helped create awareness of the Saudi cultural heritage among the participants after immersing themselves in the virtual environment. The high average score of 3.923 and an acceptable standard deviation of (0.567) suggest that the game helped create awareness of the cultural heritage among participants in Saudi Arabia. For instance, participants scored highest on learning new information they needed to have on traditional Saudi architecture. This finding concurs with earlier studies (Froschauer et al., 2012; Christopoulos et al., 2013) on the significant contribution of serious VR gaming to the participants' learning experience.

5. Conclusion and recommendations

The current study explored the application of VR gaming in promoting Saudi cultural heritage and traditional architecture through a severe gaming approach. The study suggests that VR games can consistently inspire a younger generation to approach heritage and culture in an approachable way. Most participants gave the game a good rating for enjoyment, remarking that they would play it repeatedly. The findings of the user experience questionnaire reveal that VR games may motivate young people to explore architectural and cultural heritage more, even during their free time. The study alludes that virtual reality games that combine entertainment and educational content have the potential to improve understanding of culture and

heritage among the Saudi population. The intention is to dispel the negative connotations that so many users have formed through time with learning games that were initially poorly developed, with no sense of enjoyment. Although there were responses on the adverse effects on the participants' health, such as dizziness, most results show that virtual games may be effective instruments for encouraging young people to engage with subjects on heritage and culture.

Concisely, VR gaming can significantly boost interest in culture and history in general and motivation to study. The study findings offer general resources for individuals and researchers interested in learning about cultural heritage. In addition to providing valuable principles for creating Serious Games in this study area, the research thoroughly explained the design concepts and the implementation process. The evaluation revealed that VR games alter their players' sensitivities to aesthetics, enabling them to understand art more deeply. Additionally, the gaming setting revealed a robust user experience, which indicates that players are typically at ease when using the game.

6. Future research

Future studies should integrate multiplayer functionality and an online service that enables the creation of dynamic material to achieve dynamic learning objectives. Moreover, there should be attempts to evaluate if the game can hold players' attention for several hours by running lengthier test sessions. It is essential to repeat the test frequently, after a year, to examine the long-term effects of the VR games. It will be crucial to keep looking into the potential of digital game-based learning and serious games in the domain to discover new ways of presenting the objects of Saudi cultural heritage to the younger generation.

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