

# The Preservation of Heritage in a School Campus with Augmented Reality (AR) and Game-Based Learning

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**Keywords:** Augmented Reality, Game-Based Environment, Cultural Heritage, Serious Games, Situational Interest.

**Abstract:** Serious games have showcased tremendous potential in transforming the way we teach and learn. This paper explores the potential affordances of Augmented Reality (AR) game-based learning, specifically in the context of preserving school heritage. The AR game-based learning experience is proposed to increase students' knowledge of their school's heritage. By incorporating digital technology and story-telling, the game is also proposed to make the subject of school heritage more tangible for the enhancement of learning. The study involves 10 students playing an AR adventure role-playing game (RPG) which uses device location within the campus of Hwa Chong Institution, Singapore, to trigger in-game events. To assess the effectiveness of the AR game-based experience as a medium for learning, a general survey is used to collect feedback about the gameplay experience, while a Situational Interest survey collects data about participants' situational interest, which emerges in response to the learning environment created, using the Situational Interest Scale (Chen et al., 1999). Results confirmed a positive correlation between players' situational interest and absorption of information, shed light on the significance of game design elements in influencing the gameplay experience, and pointed to specific rooms for improvement for future AR game-based learning environments. It is hoped that this paper will contribute to an understanding of the wider effectiveness of game-based learning environments in educational contexts.


## 1 INTRODUCTION


### 1.1 Background


#### 1.1.1 Serious Games and Game-Based Learning

Serious Games (SGs) are video games where the main purpose is not entertainment (Manuel et al., 2019). Game-based learning, i.e. serious games used for education, is defined as "learning that is facilitated by the use of a game" (Whitton, 2012). Game-based environments are effective in enhancing students' learning through promoting experimental learning and active construction of knowledge i.e. learning through experience or learning-by-doing (Liarokapis et al., 2017; Cozza et al., 2021). Their success has also been linked to alignment with proven pedagogy.

Use of SGs for school heritage awareness and preservation can be classified under "place-based learning", which is defined as "learning that is rooted in what is local—the unique history, environment, culture, economy, literature, and art of a particular place" (Smith and Sobel, 2010). For example, Wisconsin, a state in the United States (US), used location-based games (LBGs) for the Greenbush Cultural Tour, a year-long learning project that involves students helping to develop an AR-based game "MadCity Mystery". Through repeated observations and hands-on experiences with elements in the "Place", students form a pattern of culture and community which deepened their sense of place and connection to Greenbush (Olson and Wagler, 2011).

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### 1.1.2 Augmented Reality

Augmented Reality (AR) technology, defined as the augmentation of the physical real-world environment through the addition of virtual computer-generated information (Carmigniani and Furht, 2011), is commonly used to enhance game-based learning environments. Ying et al. (2021) attribute this to the elements of gamification and immediate feedback that can capture and retain learners' interest and attention. It is proposed that contemporary game-based learning environments should employ AR technologies for student-centred learning instead of relying on expert-led instructional methods (Lim and Lim, 2020).

### 1.1.3 Situational Interest

Situational Interest is defined as a temporary state aroused by specific features of a situation, task, or object (Schiefele, 2009). Many studies have associated students' situational interest in learning activities, which encompasses factors such as enjoyment, curiosity, and attention, with better learning and knowledge absorption. Chen et al. (1999) developed a Situational Interest Scale to identify high interest versus low interest activities.

### 1.1.4 Learning of School Heritage

School heritage is the cultural heritage of an educational institution, which refers to any tangible and intangible assets inherited from the past of that institution. Balela and Mundy (2015) outlined the following four dimensions of cultural heritage: Arts and Artefacts, Environment, People and History.

While SGs have generated significant enthusiasm in the field of cultural heritage preservation (Yun, 2023; DaCosta and Kinsell, 2023), there is a noticeable lack of representation when it comes to school heritage preservation. In undertaking this study, we consider the heritage and history of a school as something to be valued and passed down to future generations. Familiarity with school heritage is assumed to be able to strengthen the bonds within the school community, consisting of students, alumni, and staff.

This study seeks to investigate whether the proposed benefits of game-based learning environments with regards to the learning of cultural heritage and triggering situational interest, can be applied to the preservation of school heritage. For example, location-based games (LBGs) have been praised for its effects in stimulating students' imagination (Lehto et al., 2020), improving learning

motivation (Volkmar et al., 2018), encouraging reflection on history (Jones et al., 2019) and fostering emotional connection to cultural heritage (Othman et al., 2021).

Hwa Chong Institution in Singapore was chosen as the basis of the game designed in this study. The school was founded in 1919 and boasts a rich heritage, having been through World War II and bearing witness to student activism throughout the 1930s to 1960s (Liu and Wong, 2004). As a Special Assistance Plan (SAP) school that seeks to "develop effectively bilingual students who were inculcated with traditional Chinese values" (Sim, n.d), the school plays an important role in promoting Chinese culture in an increasingly diverse Singapore. The abundance of urban legends and ghost stories based around the school's history, also known as "informal, non-official heritage" (Barrère, 2016) have inspired some elements in the game's narrative, such as talking statues with glowing eyes and mysterious ghost figures loitering around the Clock Tower.

## 1.2 Scope of Investigation

This project explores the potential affordances of Augmented Reality (AR) game-based learning in preserving school heritage, by assessing student players' situational interest in a game based in their campus as well as their perception of the strengths and limitations of the medium.

Our objective is ultimately to explore the potential affordances of AR in making school heritage more tangible as a means of preservation.

## 2 METHODOLOGY

### 2.1 Location-Based Game

A game-based learning activity using Augmented Reality (AR) was designed using the Taleblazer platform developed by the MIT STEP lab, and set in Hwa Chong Institution, Singapore. The study involved 10 student participants from the school, to afford them a scaffolded experience as they explore the campus with a heritage perspective.

The game was constructed as an AR adventure role-playing game (RPG) which uses device location within the boundaries of the campus to trigger in-game events. Players were required to physically access points of interest (POIs), identified with markers on the in-game map (Figure 1).



Figure 1: Screenshot of the in-game map with the first POI marked by the red triangle icon.

As an adventure RPG, the game’s narrative revolves around an unnamed playable character (“the player”) assisting a mysterious ghost figure in its search for strange ‘shards’ around the school (Figure 2).

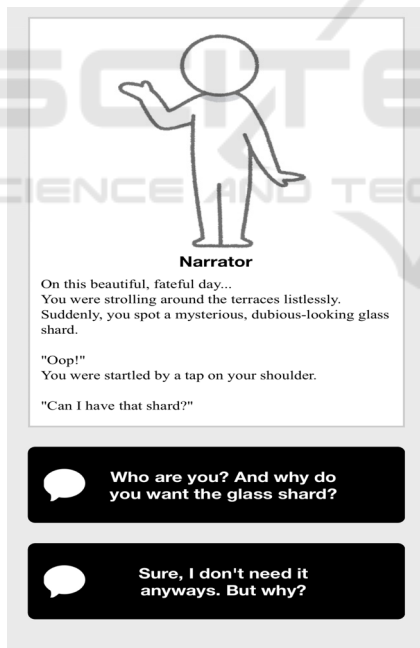


Figure 2: A screenshot of the game at the first POI, where players are introduced to the mysterious ghost figure.

The players were required to access each POI in order to progress through the game story. For the sake of simplicity usually preferred for school tours, the order of the POIs is linear with a fixed ending (Figure 3).

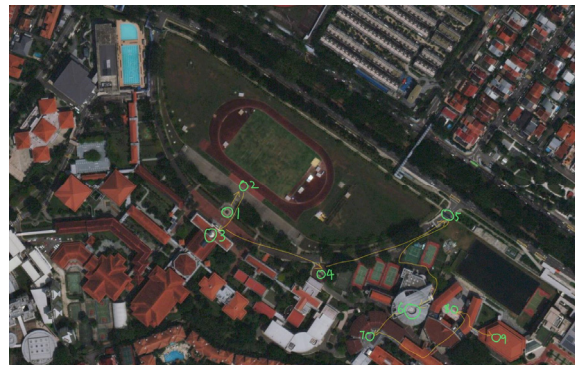
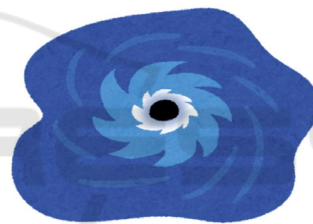


Figure 3: A bird’s eye view map of the school campus, with the sequence of in-game POIs marked in green.

With each POI reached and a new shard is collected, players discover more information about the school’s heritage and finally unveil the identity of the ghost at the last POI (Figure 4). Information was given through in-game narration, dialogues between the player and the non-playable characters (NPCs), or multimedia resources embedded in the game.



### Mysterious Portal

"Haha, well, no." The figure says. "It's hard to describe, but I am actually an entity formed by the collective 'spirit' of the school. Quite literally, the 'school spirit', you know what I mean?"

"Huh.... So it's true that strong emotions form supernatural beings?" You asked.

"Hm. I am right here, so I guess there's some truth to that. I believe I am what is called a Tudigong in some beliefs," The figure answers. "Once again, thank you for helping me regain my scattered memories and power from around the school."

"You know they say, 'the earth remembers'?" I think at some point of time, people dwelling on this piece of land began to forget about its heritage, so my powers started to seep away along with my own memories."

"I'm glad to have been on this journey with you, and I have one last favor to ask of you.

Remember the things you learnt along the way and pass it to others around you. Continue making new memories here and build on to our traditions. Keep the school spirit alive (literally)!"

Figure 4: A screenshot of the game showing part of the narration and the dialogues between the player and the non-playable “supernatural” character.

The multimedia resources served to complement the textual information given to players through character dialogues and narration, such as

photographs of past school events, and links to a website with a maneuverable 3D model of a heritage monument on the campus (Figure 5).



Chinese High School Clock Tower Build...  
3D Model

Figure 5: A maneuverable 3D model by the National Heritage Board of the Clock Tower national monument on the Hwa Chong Institution campus, which players access during the game.

Quiz segments were included in the game (Figure 6) to prompt players to search for relevant information either in the physical environment or on the internet, such that the learning activity is meaningfully situated in a relevant context (de Souza e Silva and Delacruz, 2006).

## 2.2 Research Design

A mixed methods concurrent triangulation design was adopted in this study to combine qualitative and quantitative approaches. Quantitative data from the Situational Interest Scale (see 3.3) and qualitative data from participant feedback (see 3.2) were compared to determine if there is convergence, differences, or some combination (Creswell, 2009).

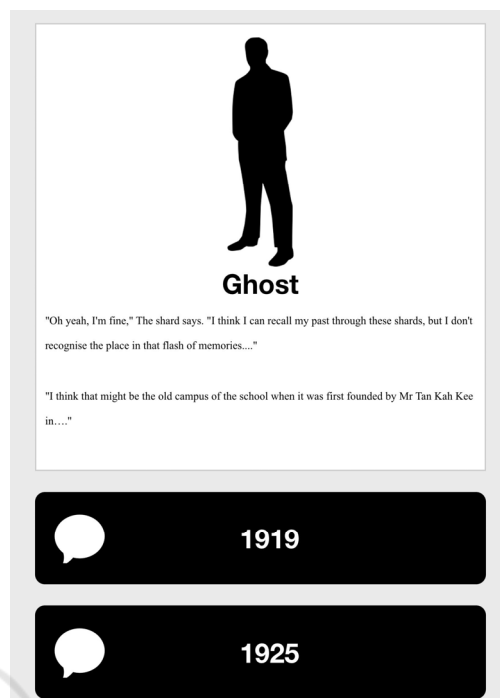


Figure 6: A screenshot of one of the quizzes in the game.

## 2.3 Situational Interest Scale

This study used the Situational Interest Scale devised by Chen et al (1999), which includes 24 items spread across 5 dimensions of situational interest– *Novelty*, *Challenge*, *Exploration Intention*, *Instant Enjoyment*, and *Attention Demand*– as well as the Total Interest domain. Each item was to be scored on a 5-point Likert scale, with 5 being Very true. The items of the Exploration Intention dimension were modified from the original context in physical education to fit the AR game-based learning activity in this study.

In the study, the items were shown to participants in a randomised sequence using a Google Form survey which also collected qualitative feedback.

The participants played the game on campus under the researcher’s supervision. Subsequently, the survey hosted on Google Forms was disseminated via WhatsApp text and completed by the participants individually.

## 3 RESULTS

### 3.1 Content Retention

The student participants were asked to score how much they knew about their school heritage before

and after the game on a 5-point Likert scale, with 1 being Not at all. The knowledge score increased from a mean score of 2.1 before the game to 4 after the game, showing content retention from the game in the short term. However, further data collection for long-term content retention was not undertaken due to the time frame given for the study.

### 3.2 Thematic Analysis

In this study, a Google form was used to collect qualitative feedback on the game experience from all participants, with the following prompts:

1. What did you like about the game?
2. What did you not like about the game?

The data was first read without coding. Then, individual statements were analysed to highlight significant text, such as “narration”, “plot”, and “GPS” (Global Positioning System), and categorised into the limitations and strengths of the game. To minimise interpretation bias, 2 researchers were involved in reviewing the data. The themes that ultimately emerged from the analysis were Content, Game Mechanics, and External Factors (see Appendix A).

Many players chose to comment on the game’s narrative, plot, or dialogues, which indicates that their situational interest is influenced by these factors. In particular, participant P8, the only one who proposed the game should have a branching storyline instead of a linear one, also had the lowest average score for Exploration Intention.

The game’s laggy GPS was pointed out by 3 out of the 10 participants, which is more than that of any other limitations. This could be because such technical problems take away the immersion factor that AR game-based environments are often praised for, or simply because the obstruction to the gameplay is a source of annoyance for players. Regardless, it meant that players considered technical problems in the game mechanics to be a critical limitation, which corroborates our literature that inaccurate GPS signals can cause unpleasant gaming experiences (Fränti and Fazal, 2023).

### 3.3 Situational Interest Scale

The scores of 10 student participants for the Situational Interest Scale (Chen et al., 1999) were recorded. The distribution of the participants’ scores in the 4 dimensions and also the Total Interest domain is represented on the respective histograms.

All items in the scale were scored on a 5-point Likert scale, from 1 (Very untrue) to 5 (Very true). A total of 24 items were shown to participants in a randomised order to check consistency in answers, and reverse coding was not used. The individual participant’s score for each dimension of the scale was recorded by taking the mean score of their answers to the 4 items under the respective dimensions.

For the Exploration Intention dimension, Figure 7 illustrates that 70% of the participants fall within the range of 3 to 5. The participants with mean scores below 3 in this dimension suggested distinct limitations of the game experience across content presentation and game mechanics, from the game’s lack of a “branching storyline”, lack of coverage on “more secluded places that we usually don’t go to”, to the game design which requires players to walk. The player feedback substantiates existing literature that a location target layout that creates a clear linear sequence may not present a sufficient challenge and, in turn, reduce player enjoyment (Schiefele, 2009).

2 out of 3 participants with mean scores of 4 and above noted the content presentation of an “interesting”, “coherent” narrative as a strength, while the other participant falling in this range indicated the game’s incorporation of information that can be found physically to be a strength.

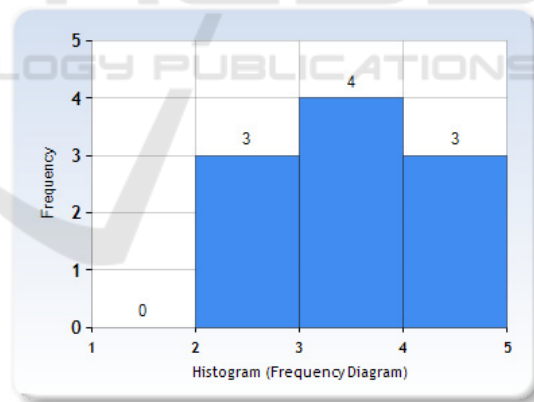


Figure 7: Histogram of Exploration Intention dimension.

Figure 8 shows that 90% of the participants scored the Instant Enjoyment dimension positively with mean scores of 3 and above. Of the 5 participants falling in the 4 to 5 score range, 4 highlighted content presentation as the strength of the game. It stands as a logical inference that content presentation is a key influence on enjoyment. The outlier participant who had a mean score below 3 in this dimension particularly mentioned a lack of interest in the topic of the game.

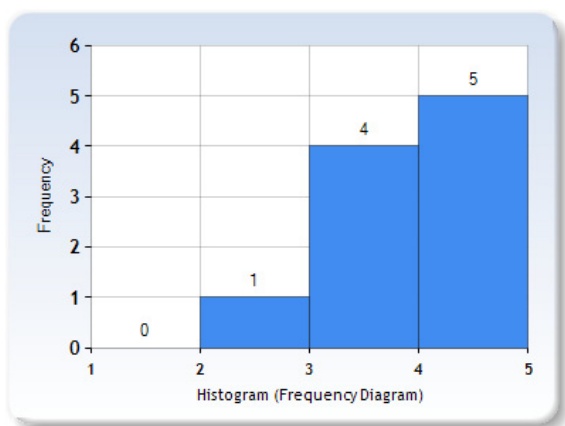


Figure 8: Histogram of Instant Enjoyment dimension.

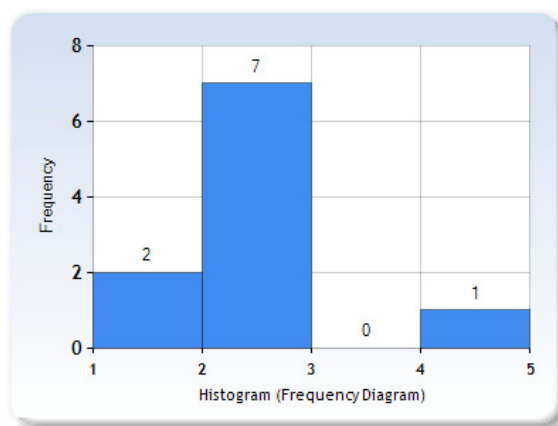


Figure 10: Histogram of Challenge dimension.

In the Attention Demand dimension, 90% of the participants had mean scores of 3 and above, as represented by Figure 9. It is significant to mention that all 4 participants falling in the highest score range of 4 to 5, also scored 4 and above in the Instant Enjoyment dimension. This aligns with reasonable expectations that the participants who enjoyed the game the most also had higher attention quality during the experience, as enjoyment has been linked with better concentration in students (Lucardie, 2014). It was noted that the outlier participant scoring below 3 in this dimension was also scoring below 3 in the Exploration Intention dimension, citing the walking required by the game as a limitation.

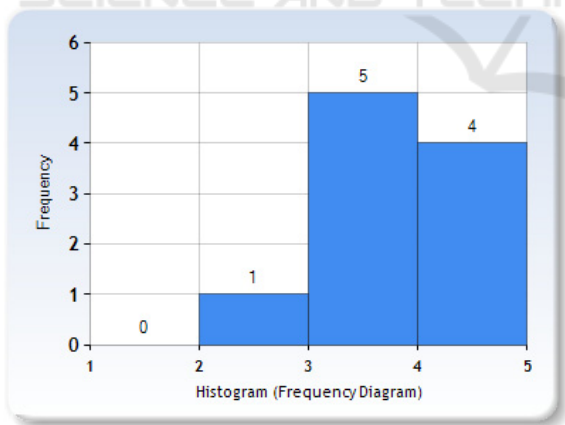


Figure 9: Histogram of Attention Demand dimension.

With regards to the Challenge dimension, 90% of the participants faced little to no challenge playing the game, as evidenced by Figure 10. It is worth highlighting that the outlier participant in this dimension was observed struggling to find the correct answer for some quiz segments in the game, which may have impacted the score.

Figure 11 illustrates that 90% of the participants scored the Novelty dimension at 3 or above, supporting our literature review that there had not yet been a widespread application of serious games in education (Almeida and Simoes, 2019) despite the increasing abundance of such games and the availability of technology.

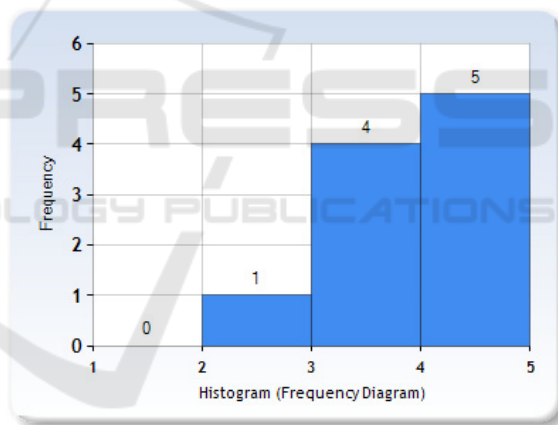


Figure 11: Histogram of Novelty dimension.

Overall, all participants positively scored the Total Interest dimension, as shown by Figure 12, indicating an overall positive and engaging game experience for the 10 participants. Referencing Figure 8, this result also substantiates the study by Chen et al. (2001) that Challenge may play a less important role in influencing situational interest, especially in the context of a task that is more physical, as the game experience constructed for this study does not require any conceptual understanding but requires physical movement.

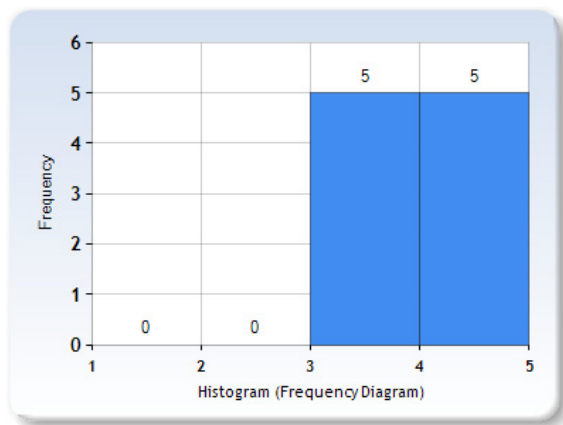


Figure 12: Histogram of Total Interest dimension.

## 4 DISCUSSION

Both quantitative and qualitative results reflected fairly similar answers across 10 participants, with reasonable outliers to support existing literature on external factors that contribute to variances in players' situational interest besides the gameplay experience itself, such as environmental variables e.g. teaching styles, learning duration or grouping (Chen et al., 2001). This reveals that, overall, HeritageByte as an augmented reality game-based learning environment has achieved an expected degree of success.

To further assess the degree of effectiveness of the gameplay experience, we rely on 2 criteria - *situational interest* (which we sometimes refer to interchangeably with *player enjoyment*) and *content retention*. On situational interest, 100% of participants indicated some level of interest (see Figure 10), which is significant because our literature review has established interest and general engagement as important factors in learners' motivation. On content retention, 100% of participants indicated an increase in their knowledge of the subject matter (i.e. the heritage of the school) after the game by at least 1 point on a 5-point Likert scale. This result corroborates the literature on the potential of hybrid reality games in teaching site-specific history (de Souza e Silva and Delacruz, 2006). This also substantiates existing literature that serious games can “[provide] concrete, compelling contexts” for cultural heritage content which may be harder to appreciate when de-contextualized (Economou, 1998; Belotti, 2012).

An unavoidable limitation of any serious games used for the learning of school heritage is the presence of players' inherent prejudice against history as a

boring, tedious and content-heavy topic. This is one of the key motivations behind the increasing incorporation of serious games into the teaching of these topics. Specifically, the potential of serious games as a medium for heritage learning is due to the belief that the fun and engaging gameplay experience is able to combat learners' previous lack of interest in the topic, which is to say, triggering sufficient situational interest for them to voluntarily learn more about the topic. However, in our study, despite the use of a serious game, which was unanimously agreed on by all players as being able to pique their enjoyment (Instant Enjoyment) and curiosity to learn more (Exploration Intention), one participant (P2) still noted the lack of interest in the topic as the factor that had significantly reduced their interest in the game. It could either be perceived as an outlier or that the design limitations of the game raised by various other players had reduced the overall effectiveness of the game.

In addition, a small sample size was used in this study due to time restraints. The student participants involved in this study were aged 17-18 years old, hence the findings of this study may not apply to other learner groups, for example, younger children, due to factors such as the development of sustained attention (Hobbiss and Lavie, 2024). Additionally, the game used in this study was constructed around the specific heritage context, and unique geography of the campus chosen. Hence, future research is required to attain a deeper understanding of principles of design that apply to all campuses in developing such location-based games.

## 5 CONCLUSIONS

This project aims to explore the potential for a more widespread application of AR game-based learning environments in delivering content about school heritage. Overall, our results corroborate existing research on the effectiveness of this medium in producing positive knowledge retention and engagement during the learning process.

The study shed light on the significance of game design elements, including the presentation aspect e.g. narrative, and the technical aspect e.g. GPS, on players' situational interest. Most significantly, the content presentation aspect of the game had a strong positive influence on the Instant Enjoyment and Exploration Intention dimensions, which suggests the narratives employed in the adventure RPG genre positively influence situational interest in this use case. We can conclude that narratives in AR game-based environments may be key to making school

heritage more tangible, as a means of preservation. Future work can delve into the relationship between specific game elements and the dimensions of situational interest to develop design principles in crafting such AR game-based experiences.

Feedback on the game's lack of branching narratives and lack of content coverage on more niche locations corroborate the common perception of serious games being too boring and predictable to keep players engaged. Whereas these limitations were deliberate design choices to ensure a reasonable walking distance in a single game session (Fränti and Fazal, 2023), it raises the question of the balance between the pedagogical and entertainment aspects of such a serious game. More secluded locations and branching narratives in a location-based game, where learning tasks are connected to relevant POIs, will likely deviate from the "serious" aspect of the game but may increase player motivation through perceived in-game autonomy (Ryan et al., 2006). Future work should consider carefully the balance between the "serious" and "game" aspects while designing game-based learning environments to ensure both entertainment and education criteria are met (Manuel et al., 2019).

Ultimately, this study was fruitful in gaining some insight into the potential of employing AR game-based learning environments in the subject of school heritage preservation.

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## APPENDIX A

Table 1: Table showing thematic analysis of qualitative feedback from participants, who are represented as the letter P and are numbered from P1 to P10 for anonymity.

Strengths	
Content (Presentation)	<ul style="list-style-type: none"> <li>● P2: “I like the positive, funny narration.”</li> <li>● P3: “Cute and interactive”</li> <li>● P5, P7: “The dialogue”</li> <li>● P8: “Uses various forms (eg videos, 3D models) to teach concepts</li> </ul>
Content (Plot)	<ul style="list-style-type: none"> <li>● P1: “Very interesting plot.”</li> <li>● P9: “the trail was meaningful and the storyline was coherent”</li> </ul>
Game Mechanics	<ul style="list-style-type: none"> <li>● P10: “info we can actually find instead of guessing randomly”</li> <li>● P6: “it was a new way to explore the school”</li> <li>● P4: “It’s quite easy to play”</li> </ul>
External Factors	
Limitations	
Content (Presentation)	<ul style="list-style-type: none"> <li>● P1: “it wasn’t narrated out loud. It would have been more interactive if it [was]”</li> <li>● P4: “The dialogues could be a bit longer”</li> <li>● P5: “few dialogue”</li> </ul>
Content (Plot)	<ul style="list-style-type: none"> <li>● P8: “No branching storyline”</li> <li>● P6: “Could have been to more secluded places that we usually don’t go to”</li> </ul>
Game Mechanics	<ul style="list-style-type: none"> <li>● P7: “The fact that I had to walk”</li> <li>● P3, P9, P10: Lagggy GPS</li> </ul>
External Factors	<ul style="list-style-type: none"> <li>● P2: “the thing is I don’t like the topic [on the school]”</li> </ul>

## APPENDIX B

This study involves the use of the Situational Interest Scale proposed by Chen, Darst & Pangrazi (1999).

The Situational Interest Scale includes 5 dimensions: Exploration Intention, Instant Enjoyment, Attention Demand, Challenge and Novelty, excluding Total Interest. There are 4 items per dimension, and 4 items for Total Interest, making up a total of 24 items. Revisions were made to the Exploration Intention dimension to fit the context of the study without changing the original meaning of the statements.

Participants were required to rate each statement on a 5-point Likert scale from 1 (very untrue) to 5 (very true). Statements were randomly placed in the questionnaire completed by participants.

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### Exploration Intention (original):

- I want to discover all the tricks in this activity.
- I want to analyze it to have a grasp on it.
- I like to find out more about how to do it.
- I like to inquire into details of how to do it.

### Revised statements to adapt to the context of the study (AR game-based learning):

- I want to discover all the information that was in the game.
- I want to study the information in the game in detail to have a grasp on it.
- I like to find out more about the information given in the game.
- I like to inquire into the details of the information in the game.

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### Instant Enjoyment:

- It is an enjoyable activity to me.
- This activity is exciting.
- The activity inspires me to participate.
- This activity is appealing to me.

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### Attention Demand:

- My attention was high.
- I was very attentive all the time.
- I was focused.
- I was concentrated.

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### Challenge:

- It is a complex activity.
- This activity is a demanding task.
- This activity is complicated.
- It is hard for me to do this activity.

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### Novelty:

- This activity is new to me.
- This activity is fresh.
- This is a new-fashioned activity for me to do.
- This is an exceptional activity.

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### Total Interest:

- This activity is interesting.
- This activity looks fun to me.
- It is fun for me to try this activity.
- This is an interesting activity for me to do.

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Cronbach's  $\alpha$ : .78, .80, .90, .91, .90 for above dimensions respectively.