Human-AI Interactions in AR for Museum Serious Games

Christos Koulouris
Computer Engineering & Informatics Department
University of Patras
Rio, Greece
up1070925@ceid.upatras.gr

Stylianos Mystakidis
Museum of Science and Technology
University of Patras
Rio, Greece
smyst@upatras.gr

Athanasios Christopoulos
University of Turku
Turku, Finland
atchri@utu.fi

Andreas Komninos
Computer Engineering & Informatics Department
University of Patras
Rio, Greece
akomninos@ceid.upatras.gr

Ioulia Simou
Computer Engineering & Informatics Department
University of Patras
Rio, Greece
simo@ceid.upatras.gr



Figure 1: The developed Augmented Reality application, including user interaction and interface views.

Abstract

We present preliminary experiences with a serious museum game, integrating Augmented Reality (AR) with a Generative Artificial Intelligence (GenAI)-powered conversational avatar, under solo and team play conditions. The experience is centered on a museum rescue mission in which players must locate and neutralize virtual mines hidden among telecommunication exhibits. Results of a mixed-method evaluation study provide strong evidence that the integration of AR and GenAI in a serious escape game constitutes an effective and engaging approach for enhancing museum-based learning experiences and does not detract from interpersonal dynamics during the experience.

CCS Concepts

• **Human-centered computing → Mixed / augmented reality**.

Keywords

Augmented Reality, Museums, Educational Games, Human-AI Interaction

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1 Introduction

Science museums and science centres play a pivotal role in informal education by fostering public engagement with scientific knowledge. However, maintaining the interest of younger, digital-native audiences, who are increasingly accustomed to interactive and immersive media, remains a significant challenge. This issue is particularly pronounced in museums that curate science, technology and cultural heritage collections, where traditional static exhibitions often fail to sustain visitor engagement. Such exhibits have been associated with museum fatigue, a phenomenon characterized by reduced attention, cognitive overload, and diminished

information retention resulting from physical and mental exhaustion [2]. To address these challenges, the present project harnesses the synergistic potential of Augmented Reality (AR), Generative Artificial Intelligence (GenAI) and serious games to offer a playful and interactive experience at the Science and Technology Museum of the University of Patras. AR can be integrated with a variety of gameful approaches to enhance learning and engagement in both formal and informal educational settings [1, 4, 6]. Prior literature has also highlighted the importance of supporting shared AR experiences in museums, which can increase communication and engagement among visitors [5]. Building upon this potential, we propose an intelligent collaborative serious game mobile application that superimposes a dynamic digital narrative onto the physical museum environment. By combining AR-based interactions with smart GenAI-driven adaptive guidance, the application enables visitors to jointly investigate museum exhibits, transforming them from passive observers into active participants who engage in inquiry, problem-solving, and meaningful knowledge construction. The GenAI conversational guide is based on recent advances in integrating Large Language Models (LLMs) into XR environments, which have shown the potential of conversational AI to enable more natural and immersive experiences [3, 7].

2 Silent Signal: Design and Development

The game narrative features a clandestine group of cyberterrorists who planted virtual mines on museum exhibits, threatening its operation and educational mission. Invisible to the naked eye, these digital threats can only be detected and neutralized through the user's AR-enabled mobile device, establishing a sense of purpose and urgency. Designed around human-AI collaborative exploration, the game allows solo play, but we also explored use by participant pairs working together with the AI, to jointly inspect exhibits, discuss clues and coordinate their actions. The puzzles focus on selected museum exhibits and require visitors to actively engage with the historical context and functionality of each artifact. The game comprises three progressively challenging missions, represented as virtual mines that must be disarmed. To sustain motivation, a dynamic progress bar provides immediate feedback after each successful challenge, culminating in the completion of all three puzzles and the successful rescue of the museum. Throughout the experience, visitors are assisted by Echo, a GenAI-powered virtual guide embodied as a 3D avatar. To maintain engagement, Echo functions as an interactive conversational agent rather than a passive information provider. Instead of delivering direct answers, Echo offers adaptive scaffolding through natural spoken dialogue, encouraging inquiry, exploration and collaborative problem solving.

3 Empirical Evaluation

The educational effectiveness and usability of the serious game was evaluated through an empirical study with 36 university students. In addition, the research featured a comparative element. All participants played two versions of the game; single-player and collaborative with 2-person teams, with the order of presentation counterbalanced across participants. In the paired condition, a single device held and controlled by one participant was used. A mixed-methods research design was employed, combining structured questionnaires grounded in the Technology Acceptance Model and Flow Theory with automated gameplay analytics. The findings regarding the game's usability indicated exceptionally high levels of user engagement and flow (Median = 5.0 on a 5-point Likert scale). Participants also rated the effectiveness of the GenAI assistant very highly (Median = 5.0). Automated conversational analysis using BERTopic revealed that most interactions with the game's virtual assistant focused on puzzle-solving support (64% of messages), rather than social conversation. Furthermore, gameplay analytics showed a 100% puzzle completion rate with time to complete being slightly shorter in the team condition ($\bar{x} = 23.19m, \sigma = 6.89$) vs the solo condition ($\bar{x} = 25.34m, \sigma = 7.21$). Collectively, these findings provide strong evidence that the integration of AR and GenAI in a serious escape game constitutes an effective and engaging approach for enhancing museum-based learning experiences. The comparison between the two versions indicated that both were equally acceptable, with no statistically significant overall preference. Nevertheless, 78% of the participants found the collaborative version more effective for solving riddles. On the other hand, participants felt slightly more focused in the solo version although no significant difference was detected. Regarding the role of the GenAI companion, 41% felt it was equally useful in both versions, while 36% stressed its importance for the single-player experience. Interestingly, the non-device participants in paired play did not report any feelings of exclusion from the game.

4 Conclusion

The evaluation of this serious game proved that AR and GenAI technologies are mature enough to produce relatively low-cost mobile serious games with satisfactory performance. Further analysis is required to investigate how AI companions affect human-human interpersonal behaviour during co-located visits and play.

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