

# Design-based research as a framework for developing and deploying augmented reality applications and scenarios for intercultural exchange

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**Abstract.** This paper delves into the underlying phases involved in designing, developing, and deploying Augmented Reality (AR) applications and game-based scenarios that will be implemented during intercultural exchanges among students in two different academic institutions in Sweden and Cyprus. Building on principles of design-based research (Barab & Squire, 2004; Klopfer & Squire, 2008), the aim is to expand the learning ecology by leveraging instructional tools and developing novel scenarios to broaden the trajectories of collaboration, intercultural understanding and communication, and cultural knowledge. The AR applications and scenarios are in the process of being developed as part of the Digital Methods Platform for Arts and Humanities (DiMPAH) project, where game-based activities will foster intercultural collaboration, exploration of cultural heritage sites, intercultural understanding, knowledge, and interaction. Adopting a bottom-up approach, instructors collaborate with a software developer and an extended research team to design pedagogically and culturally potent scenarios embedded in novel technologies that bring the virtual into the physical world.

**Keywords:** augmented reality, intercultural exchange, design-based research.

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## 1. Introduction

The integration of design-based research principles to investigate the affordances and complexities involved in the design and development of software and applications for learning has incited discussion on the pedagogical, design, and technological implications of these technologies (Klopfer & Squire, 2008; Scott, Wenderoth, & Doherty, 2020). Design-based research captures the iterative nature of the design and development processes within the naturalistic contexts that they unfold, as well as the new theoretical trajectories and practices that emerge (Barab, 2014). As Anderson and Shattuck (2012) postulate, design-based research “evolved near the beginning of the 21st century and was heralded as a practical research methodology that could effectively bridge the chasm between research and practice in formal education” (p. 16). Multiple studies have been conducted in various formal educational contexts, with particular emphasis being placed on science, technology, engineering, and Math-related subjects (40.6%), while only 21.9% of these studies delved into the arts and humanities, including language learning (Bacca et al., 2014). As part of the three-year long European funded project DiMPAH, this study investigates the multiple iterations involved in the design and development of AR applications and scenarios for intercultural exchange.

In this paper, the key phases involved in the inception, design, development, and elaboration of a working architecture, as well as in the testing, modification, realization, and implementation of the AR apps, are explored. Within this ecology, clashing forces emerge as this collective design activity is intended to enact game-driven AR-mediated applications and scenarios that enclose further pedagogical, learning, and technological implications. On one hand, tailored pedagogically-driven scenarios designed to meet learning needs and promote intercultural exchanges call for a collective interdisciplinary endeavor. On the other hand, this collective endeavor adds to the complexity and demands of the design of these AR applications and scenarios. Customizable AR applications and scenarios call for a collective effort to design game-based activities for higher education students that offer imaginary experiences with real-world pedagogical, social, and historical implications. They form a tool for exploring and understanding cultural heritage, negotiating meaning, and engaging in mystery game-driven experiences during intercultural exchanges.

## 2. Method

An interdisciplinary pool of instructors, researchers, and a software developer from Sweden and Cyprus identified four culturally and historically salient sites in their

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countries. In this paper, the focus is placed on the Neolithic settlement of Choirokoitia and the Iron age ringfort of Sandby borg. Drawing on the mystery involved in the disappearance of Choirokoitia residents and the Sandby borg massacre, this research team is designing and developing AR-mediated scenarios. The virtual settings of Choirokoitia and Sandby borg will be enriched with interactive 2D and 3D artifacts, avatars, and settings. Through multiple collaborative activities, students will explore customs, cultural traditions, language, beliefs, communities, and shared values within each society. Students will engage in multiple game-driven activities while participating in intercultural exchanges to solve mysteries. To develop a better understanding of the processes involved in the design, development, and implementation of these AR scenarios, a case study approach is used as a guiding principle. Expanding on [Klopfer and Squire's \(2008\)](#) work, seven phases are proposed to examine the underlying processes involved in the scenario design.

### **3. Results and discussion**

The design process invites the contemplation of multiple and often contradictory principles, including design principles for developing AR game-based learning scenarios, user experience, and user interaction during intercultural exchanges in historically and culturally laden sites.

#### **3.1. Phase one: virtual site selection and game-driven AR-mediated scenario contemplation**

Site selection and game-driven scenarios require consideration of multiple interrelated variables and dynamics to meet the learning needs of an intercultural and interdisciplinary pool of students and at the same time to accurately depict the cultural, historical, and linguistic significance of that era. Already developed virtual sites were deployed and modified for designing activities, 2D and 3D objects, non-player characters, simulated tools, and multiple other artifacts of each era. Choirokoitia and Sandby borg presented sites that could be enriched with game-like activities using Unity game engine features and C# programming language, and involved mysteries related to the residents' disappearance or massacre.

#### **3.2. Phrase two: AR-mediated game-driven scenarios consideration**

To develop immersive, engaging, and collaborative game-driven scenarios that will enact affordances for collaborative explorations to solve a mystery, the rich historical,

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cultural, and linguistic values, as well as the importance of each civilization, the economic activity, and multiple other variables were taken into consideration. The aim is to capture and convey to users the given era, through a game-driven scenario, where they will need to investigate and derive cogent arguments on the underlying reasons that have led to the disappearance or massacre of the local residents. Both instructors and historians were consulted during this process.

### **3.3. Phase three: AR-mediated game-driven scenario prototype development**

At the current stage, the research team is focusing on the development of the prototype of both scenarios where the Unity game engine and C# programming language, along with other programming software, are deployed to design marker-based and dynamic trigger-based AR scenarios. Simultaneous localization and mapping is also deployed to stabilize tracking for AR by adjusting the predictions performed by the Inertial Measurement Unit (IMU) and the actual IMU tracking. Further, 2D and 3D objects, simulated tools, non-player characters, interactions, and multiple other features are being added to the two sites to enrich these scenarios.

### **3.4. Phase four: AR scenario pilot testing**

Upon completion of the prototype, the game-driven activities and AR-mediated scenarios will be pilot tested among both students and instructors in Cyprus and Sweden to ensure their functionality and usability, and to examine how students and instructors interact with the scenarios and AR technology, the different elements of the AR game-driven activities, object recognition, and multiple other elements that will help mediate students' intercultural exchanges. Participants' feedback will guide the research team in enhancing the AR scenarios and game-driven activities. The pedagogical and learning implications of these AR-mediated scenarios will be further explored and adapted to meet students' learning needs.

### **3.5. Phase five: AR scenario implementation during intercultural exchanges**

The AR scenarios will be implemented during intercultural exchanges among students enrolled in the participating academic institutions in Cyprus and Sweden. The goal is to enact pedagogically and culturally laden learning experiences mediated by AR applications and game-driven activities that will immerse students in problem-solving, deductive reasoning, and intercultural exchanges. Cultural knowledge and understanding, as well as interaction with

historically salient sites and artifacts will enrich students' knowledge and cultural understanding.

### **3.6. Phase six: scenario enrichment and implementation in additional contexts**

The two scenarios will be implemented in additional contexts during intercultural exchanges among students in the two participating academic institutions to further explore their pedagogical implications and added value. Additional features, artifacts, and other 2D and 3D objects, as well further modifications/adaptations to the scenarios will be made to ensure that they can enrich students' learning and collaborative activities.

### **3.7. Phase seven: scenario expansion and implementation in new contexts**

The research team has identified two additional historical sites that are available in virtual contexts and the Unity game engine and C# programming language will be integrated to design game-driven activities in these settings. Discussions also focus on making these activities more demanding and engaging, with new collaborative tasks, to further expand students' interaction, learning, and collaboration. Additional features and functionalities will also be added to enrich the sites.

## **4. Conclusions**

Within the trajectories of design-based research, this paper introduced an initial framework for examining seven phases involved in the design, deployment, and integration of AR game-oriented activities in culturally and historically rich sites. Their design and development framework is a collaborative interdisciplinary process with multiple iterations and contemplation of pedagogical and technological implications and contradictions. Their value is yet to be fully explored but their pedagogical potential should form the guiding principle for their further development and implementation in different formal institutional contexts.

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