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Project Proposal: Integration of Mixed Reality in Educational Escape Room for Self-Directed Learning in Object-Oriented Programming

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1 Background & Motivation

Self-directed learning has been widely recognized for its essential role in fostering students' critical thinking, problem-solving abilities, and intrinsic motivation, particularly in complex and abstract fields like computer science (CS). As one of the most high-potential disciplines, CS education has significantly benefited from integrating advanced educational technologies, such as large language models (LLMs) and gamification. However, a significant gap remains in promoting self-directed learning for certain challenging concepts in CS, especially in object-oriented programming (OOP), where abstract concepts can be difficult for students to grasp independently.

Given these challenges, educational escape rooms (EERs) have emerged as an promising approach to active learning and breakout traditional classroom, blending problem-solving tasks with narratives to create immersive learning experiences [1]. EERs have been applied in many academic disciplines, including computer science [2], physics [3], mathematics [4–8], biology [9], and chemistry [10]. Furthermore, as EERs are based on a game structure and design, they are linked to the methodology of gamification [1]. Students engage in subject-specific challenges within a structured, game-based environment. By requiring students to solve a series of puzzles to "escape", EERs foster critical thinking and the application of knowledge in a stimulating, time-bound setting. However, traditional physical EERs' are resource-intensive, restricted by classroom availability, budget, and a lack of time for preparation [11].

To address these limitations, several researches turned to digital educational escape rooms (DEERs) to provide greater flexibility and immersion [12]: Baziak *et al.* developed a mathematical DEER integrating Cave Automatic Virtual Environment (CAVE) technology [4]; Tsalidis *et al.* created Earscape, an auditory DEER using immersive virtual reality (IVR) [13]; Guillen-Sanz *et al.* developed an IVR escape room for teaching physiological regulation [14]. However, despite the growing interest in DEERs, few studies have explored the integration of head-mounted display (HMD) mixed reality (MR) technology, which offers unique advantages by seamlessly blending physical and virtual environments, allowing users to interact with digital objects within their physical surroundings [15].

While the fusion of real and virtual elements has been proven to provide a more intuitive and immersive experience, enabling learners to connect abstract concepts with tangible interactions [15], there is limited exploration of MR-enhanced EERs in CS education. Therefore, it's worth investigating the integration of MR to the development of educational escape room focused on CS education, especially in OOP concepts.

2 Aims & Objectives

The project aims to integrate MR technology into the development of a CS EER game, specifically focusing on enhancing self-directed learning in OOP. By combining the immersive aspects

of MR with the interactive nature of EERs, the project seeks to provide an innovative and engaging platform for students to grasp complex CS concepts, with the following objectives:

1. To investigate the influence of immersive EER gameplay on students' motivation, engagement, and self-directed learning within the context of CS education.

2. To explore how the combination of physical and virtual elements affects students' problem-solving and critical thinking abilities, particularly in applying OOP principles.

3. To examine the effects of MR visualization on enhancing students' understanding and retention of OOP concepts, by allowing them to interact with and manipulate virtual objects in a simulated EER environment.

3 Project Plan

The detailed timeline for this project is outlined in the Gantt chart below (see Fig.1). Given the research-oriented nature of the project, it begins with an extensive literature review on relevant topics, including CS education, EERs, and the integration of MR technology. This foundational phase will establish a comprehensive understanding of existing work in these areas.

Following the literature review, the project moves into the design and implementation of the MR EER game, which represents the most time-intensive phase. This stage involves various tasks, including the creation and acquisition of art assets, programming, and the design of game mechanics that align with educational objectives. Due to the complexity of integrating MR and educational elements, this phase requires careful planning and coordination across multiple domains.

Once the MR escape room game is fully implemented, a controlled experiment will be conducted to collect data on users' learning outcomes, motivation, and engagement levels before and after gameplay. The analysis of these results will form the basis for writing of a conference or journal paper, as this project is targeting academic publication. In the end, a comprehensive dissertation will be prepared, synthesizing the project's findings, methodologies, and contributions to the field.

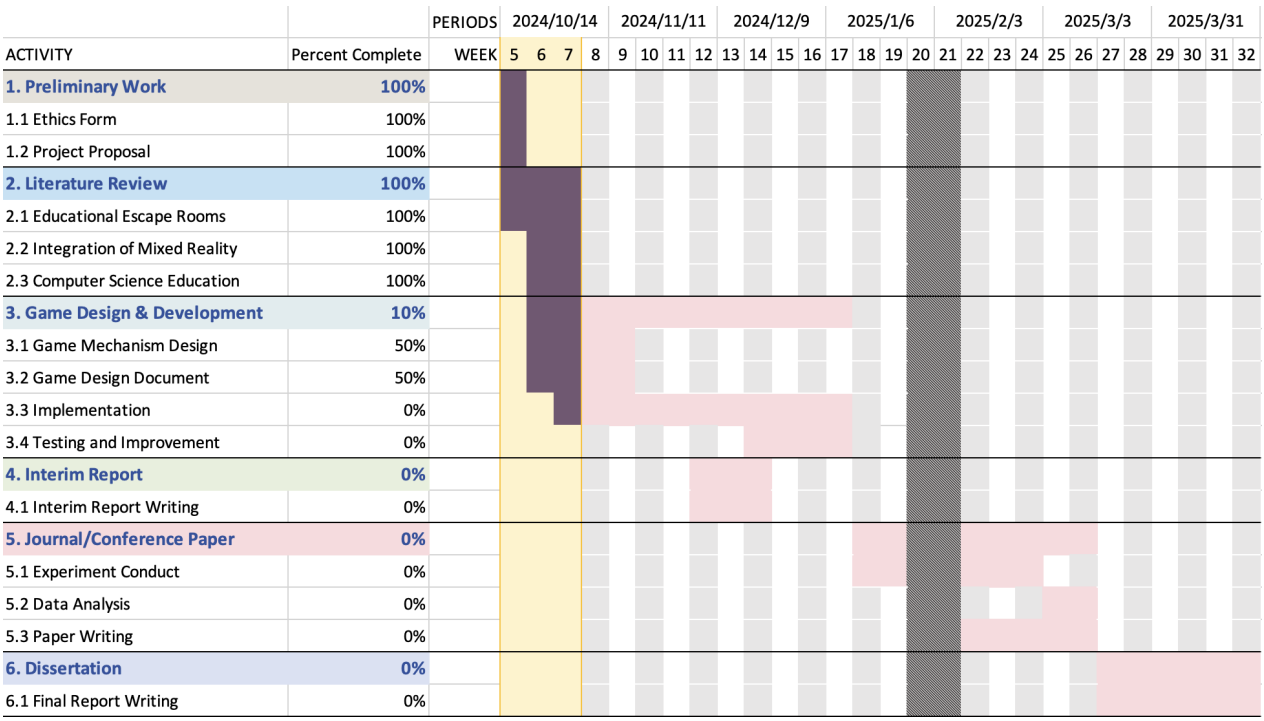

Figure 1: Gantt chart of the project timeline

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