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Virtual Mittweida—Creating a Game-Based Approach to Teach Artificial Intelligence for Games

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ABSTRACT

With the proliferation of computing technologies and an ongoing trend of introducing digital and blended learning aspects into higher education, innovative approaches to teaching complex topics like artificial intelligence (AI) have emerged. However, despite the growing use of game-based methods in fields like economics, their application in computer science—especially in teaching game AI—remains under-explored. Understanding AI is increasingly critical for game development, as modern games emulate human-like behaviour in areas such as decision-making, character routines, and adaptive strategies. This work proposes the development of a novel interactive application to fill this niche. Taking inspiration from city building and management games, the application simulates the campus of the University of Applied Sciences Mittweida, where students are given control of a system of agents acting as archetypal roles of students. Students interact with the system through an API that provides information on the state of the simulation and allows issuing commands to specific agents. Additionally, the application enables dynamic changes to the environment at runtime, such as adding or removing courses or buildings, simulating player-driven alterations to the game world. By designing decision-making algorithms for these agents, students gain hands-on experience with fundamental AI concepts, i.e. decision trees, bridging the gap between theoretical knowledge and practical application. To evaluate the effectiveness of the application, a comparative study with undergraduate students is planned. Over the course of two semesters, two groups of students will be taught the basics of game AI—one using traditional teaching methods (primarily lectures), the other using a game-based method incorporating the new application.

Keywords: Artificial intelligence, Game AI development, Simulation, Modelling, Game-based learning, Educational technology

INTRODUCTION

Video games represent a continuously expanding sector of the entertainment industry. With an increasing number of new titles released each year, the demand for innovative and engaging gaming experiences remains high. According to Newzoo's Global Games Market Report (2024), the video game industry was projected to generate $187.7 billion in revenue in 2024,

marking steady year-over-year growth. Other market analyses support this projection, indicating continued expansion in the coming years (Statista, 2024). As gaming technology evolves, one of the key drivers of innovation—alongside advancements in graphics and hardware—is artificial intelligence (AI).

AI plays a crucial role in modern game development, powering essential interactive elements such as non-player characters (NPCs), procedural content generation, and adaptive difficulty systems. While some popular multiplayer games emphasize player-versus-player (PvP) interactions, many influential single-player and hybrid multiplayer experiences rely on AI to create dynamic and immersive environments. A notable example is Alien: Isolation (Creative Assembly, 2014), where the game's AI-controlled antagonist, the alien, adapts to player behaviour by countering frequently used tactics, such as hiding in lockers. To enhance the illusion of intelligence, a secondary "game director" system monitors player progress and orchestrates the alien's appearances accordingly (Gomez-Alvarez et al., 2024). More recent advancements have leveraged large language models (LLMs) to create AI-driven interactive narratives. In AI Dungeon (Latitude, 2024), an AI functions as a virtual game master, responding dynamically to player-generated text prompts to generate an evolving role-playing adventure. Such developments illustrate the growing potential of AI in gaming, where machine learning and neural networks enable increasingly sophisticated, player-responsive experiences.

However, as AI-driven game systems are becoming more advanced, their complexity presents a significant challenge. Developing such systems requires a deep understanding of AI concepts, yet current academic approaches often emphasize theoretical foundations without providing practical, hands-on experience. This research addresses that gap by developing an interactive learning application designed to teach AI for games through a game-based approach. By integrating AI education with interactive gameplay mechanics, this study aims to provide students with a more engaging and applied understanding of AI, better preparing them for the evolving demands of modern game development.

BACKGROUND

Game-based learning (GBL) has garnered significant interest in educational research due to its potential to enhance student engagement and learning outcomes. Various frameworks have been proposed and tested to facilitate the development of serious games for educational purposes. Foundational models, such as the Game-Based Learning Foundation (Plass et al., 2015), have influenced subsequent research. For example, Roedavan et al. incorporated these principles into a comprehensive framework covering the entire development cycle of serious games (Roedavan et al., 2021). Despite ongoing gaps in these frameworks—such as the role and involvement of educators in the design process (Dimitriadou et al., 2021)—the substantial body of research on GBL underscores its pedagogical significance.

The effectiveness of GBL has been demonstrated across various educational fields. Studies have shown that incorporating game-based elements can improve student comprehension and motivation. For instance, the use of the quiz application Kahoot has been linked to increased student understanding (Saputri, 2024), while comparative analyses indicate that game-based approaches often yield superior learning outcomes compared to traditional methods (Hafeez, 2022). In the context of this study, GBL is particularly relevant for AI education, where prior research has explored its potential to enhance student engagement and conceptual understanding (Zhan et al., 2024).

At the same time, AI is transforming game development itself, enabling advancements in areas such as procedural content generation and the use of large language models (LLMs) to create dynamic non-player characters (NPCs) (Dablander, 2024). As AI-driven technologies continue to evolve, future game developers must be equipped with the necessary skills to leverage these advancements effectively. However, traditional AI education often emphasizes theoretical instruction, lacking practical, hands-on approaches that reflect real-world game development challenges. To address this gap, this study proposes an interactive learning application that integrates AI education into a game-like environment. The application, structured as a sandbox for programmable agents, offers several key advantages:

- Students can observe the immediate impact of their AI systems within a simulated game environment, making abstract AI concepts more tangible.
- Unlike static assignments, an interactive system allows students to iteratively refine AI behaviour, learning through experimentation.
- By embedding AI programming within a dynamic, interactive framework, students gain practical experience directly applicable to game development.
- Game-based simulations enhance student engagement by providing an immersive and interactive learning experience.

This approach aims to bridge the gap between theoretical AI instruction and practical application, preparing students to develop AI-driven solutions in the evolving landscape of game development.

USING A VIRTUAL UNIVERSITY TO TEACH AI

Inspired by city-building and management games, the proposed application is designed as a sandbox environment that simulates the campus of the University of Applied Sciences Mittweida. While this game style differs from genres such as first-person shooters or multiplayer online battle arenas, it offers a scalable framework in which the number of active agents can be dynamically adjusted to accommodate a wide range of test scenarios. The application consists of three key pillars:

- Environment: A virtual simulation of the university campus, including its buildings, academic structures, and processes, transformed into interactive game mechanics.

- Agents: Programmable entities representing different archetypal university roles, primarily students, who navigate the environment and interact with its mechanics.
- Interface: A dedicated API that allows users to retrieve information about the environment and agents, as well as issue commands to guide agent behaviour.

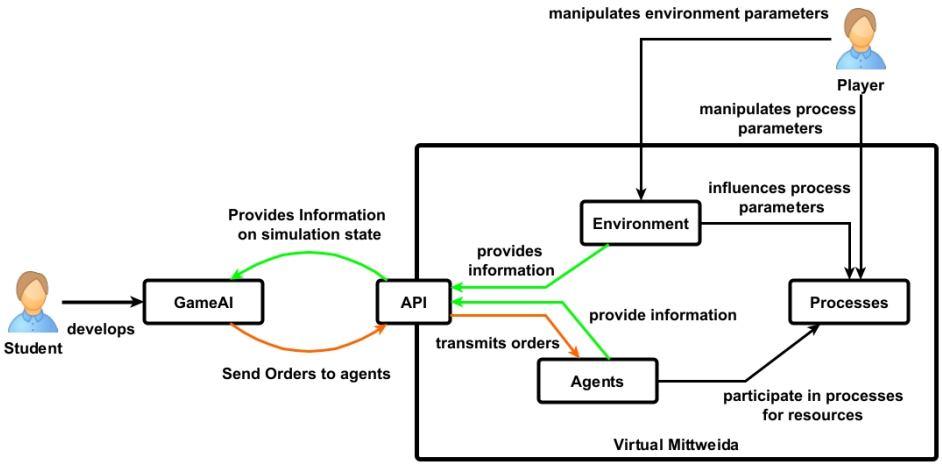

Figure 1: Schematic overview of the interactive learning application.

Figure 1 visualizes the internal workings of the interactive learning application. The green arrows mark the flow of information used by the games' AI. Based on this information, orders for individual agents are generated and transmitted via the interface (red arrows). To underline the game-like character of the application, parameters of the environment and the internal processes can be changed during runtime by a player.

By providing a structured yet dynamic environment, the application enables students to design, test, and refine AI systems in a controlled, interactive setting. The sandbox environment is modelled after the University of Mittweida, including its physical layout and academic workflows. However, real-world processes are streamlined and transformed into game mechanics to create understandable routines. For example, for students to enrol in a course, the course itself must first be created by the player. This involves selecting parameters that influence its attractiveness, affecting the number of agents who choose to enrol. By introducing mechanics that define how various parameters interact, the simulation provides an engaging framework in which students must develop AI solutions that operate within predefined constraints. The decision to base the environment on the University of Mittweida is intentional, as it provides a familiar structure for students, allowing them to intuitively relate to the simulated processes.

Agents within the simulation represent different university members, primarily students. Their overarching objective is to acquire knowledge, represented as an abstract resource gained through participation in lectures.

However, the amount of knowledge acquired varies based on a set of procedurally generated parameters unique to each agent, simulating individual differences in learning capacity. To attend lectures and gain knowledge, agents must navigate the campus, finding their way to designated locations. Additionally, external factors such as lecture quality—modifiable by the player—can influence knowledge acquisition, allowing for optimization strategies. Beyond academic pursuits, agents also possess basic needs, such as energy, which depletes over time and must be replenished. This introduces additional constraints, requiring agents to balance study-related tasks with self-maintenance activities, such as resting at designated locations. These mechanics create a more complex and realistic simulation, challenging students to develop AI solutions that account for multiple interacting variables.

The simulation includes an API-based interface that allows users to monitor both the environment and individual agents. The interface provides detailed real-time data on agent states, environmental conditions, and course parameters. Additionally, it enables users to issue commands to agents, guiding their behaviour based on the AI algorithms they develop. A key advantage of this system is its flexibility—students can interact with the application using different programming languages and frameworks, allowing them to work with technologies they are most familiar with. This accessibility ensures that students of varying skill levels can engage with the simulation effectively, focusing on AI development rather than software compatibility issues.

RESEARCH GOALS

As demonstrated in the preceding text, game-based learning could be highly beneficial to teach the development of game AI. To evaluate this possibility, this research aims to answer the following research questions:

1. Does the use of a game-based learning approach promote the understanding of AI development for video games?
2. How do students interact with an interactive sandbox in which changes in the simulated environment have an impact on the AIs they develop?
3. How do students tackle the limitations imposed on the AI by the environment and its mechanics?

RESEARCH METHODOLOGY

The research is structured into three distinct phases: In Phase 1, an interactive application will be developed using established models for serious game design. This application forms the core of the new game-based learning approach, providing a simulated environment in which students can experiment with AI development for games.

Phase 2 involves the creation of a series of assessments designed to evaluate the effectiveness of the learning approach. These tests are structured to present a series of increasingly complex problems—from basic condition checks (e.g., verifying that a specific value is reached) to more

complex challenges involving state management. These assessments will be administered throughout the semester, allowing for continuous evaluation of the students' understanding as they progress through the curriculum.

In Phase 3, the assessments will be applied over the course of two consecutive semesters. Two groups of students will be involved:

- The first group will receive instruction through traditional, lecture-based methods.
- The second group will be taught using the new GBL approach, centred around the developed application.

The learning outcomes of both groups will be compared through quantitative measures (e.g., average test scores) and qualitative analyses (e.g., the strategies employed in problem-solving). This comparative analysis will focus not only on overall performance but also on the methods students use to tackle the presented challenges, thereby providing a comprehensive evaluation of the new approach's impact on learning success.

CONCLUSION

This study proposes the development and evaluation of an interactive learning application designed to address the evolving demands of AI technology in game development. By providing students with a structured, game-based environment modeled after the University of Mittweida, this application offers a familiar and interactive setting in which to develop and test AI systems within defined game mechanics. To assess the effectiveness of this approach, a comparative study will be conducted in which two groups of students will engage with progressively complex AI development tasks. One group will be taught through traditional instructional methods, while the other will utilize the game-based learning application. The findings of this study will contribute to the ongoing discourse on AI education, exploring the potential of interactive learning environments to enhance both theoretical understanding and practical proficiency in game AI development.

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