

# An Adaptive Serious Game for Inclusive Engagement of ADHD Young Adults

Paula Escudeiro<sup>1</sup>, Sofia Resende<sup>1</sup>, and Francisca Escudeiro<sup>2</sup>

<sup>1</sup>GILT - Games, Interaction & Learning Technologies, ISEP, IPP, Porto, Portugal

<sup>2</sup>ICBAS – Instituto de Ciências Biomédicas Abel Salazar da Universidade do Porto, Portugal

## ABSTRACT

Attention Deficit Hyperactivity Disorder (ADHD) significantly affects a vast demographic of young people, often resulting in concentration difficulties that hinder daily productivity and social integration. To address these challenges, adaptive digital solutions like inclusive online games serve as vital tools for promoting equitable social participation. Ancient Dynasties: Heroes and Deities is an innovative, serious multiplayer Online Collectible Card Game (OCCG) that seamlessly integrates historical civilizations, world religions, and mythical lore. The platform provides a highly dynamic and adaptable environment specifically engineered for young adults with ADHD. By utilizing a specialized color palette, immersive soundtracks, flexible rule sets, and environmental bonuses, the game minimizes cognitive overload while maintaining engagement. A core technical highlight is the integration of Augmented Reality (AR) via Oculus Quest, which fosters a multisensory experience to sustain focus. Rated 13+ by the ESRB, the project targets competitive players while upholding rigorous academic standards. The development process successfully balanced educational complexity with entertainment, fully addressing the Qualitative Evaluation Framework (QEF). Empirical testing via the System Usability Scale (SUS) yielded a robust score of 80%, culminating in a final quality evaluation of 99%. Supported by a sustainable design of community events and continuous feedback loops, this work establishes a new benchmark for inclusive gaming. Future iterations will refine gameplay depth and technical infrastructure, reinforcing the game's dual value as a sophisticated educational resource and a high-tier entertainment tool.

**Keywords:** Serious games, Collectible card games, ADHD, Dynamic difficulty adjustment, Educational gaming, Game design

## INTRODUCTION

Digital games increasingly serve purposes beyond entertainment, including education, training, and accessibility support. Serious games, in particular, have demonstrated potential to enhance learning outcomes by embedding educational content within interactive systems. However, designing games that balance engagement, competitiveness, and inclusivity remains a challenge, especially when addressing players with cognitive conditions such as Attention Deficit Hyperactivity Disorder (ADHD).

According to Madeira et al. (2025), there are approximately 1.5% – 3% Portuguese adults who suffer from ADHD, a figure that likely excludes those

who remain undiagnosed or misdiagnosed. This condition is frequently accompanied by various psychological symptoms (Madeira et al., 2025) that significantly impact daily life, including social interactions, anxiety levels, and cognitive skills. Consequently, it is essential to promote adaptive solutions, such as inclusive online games, to ensure that everyone has the opportunity for equitable social participation.

*Ancient Dynasties: Heroes and Deities* is a serious multiplayer Collectible Card Game meticulously developed to showcase and educate players about ancient civilizations and their complex religious mythologies. A core pillar of the project is its inclusive design philosophy, specifically tailored to accommodate the cognitive needs of the ADHD demographic. This is achieved through a structured yet engaging environment that balances a standard ruleset with a sophisticated ranking system. This system dynamically scales match difficulty based on player proficiency, ensuring that high-skilled users remain challenged while providing clear, attainable objectives for all participants.

To foster creativity and agency, the game incorporates a custom match feature, empowering players to modify and combine core mechanics to create personalized gameplay experiences. Beyond traditional mechanics, the project integrates innovative technologies to deepen immersion. Geolocation data can be leveraged to grant environmental bonuses during matches, bridging the gap between the physical and digital worlds. Furthermore, players can opt for an enhanced experience using augmented reality via Oculus Quest, providing a more tactile and visually immersive interface. To ensure long-term engagement and educational growth, the game will be supported by periodic downloadable content (DLC), introducing new historical card sets and aesthetic customizations that expand the narrative and strategic depth of the platform.

Collectible Card Games (CCGs) offer a strategic and modular structure well-suited for educational integration. Their turn-based nature supports deliberate decision-making, while deck-building enables personalization and replayability. This paper introduces *Ancient Dynasties: Heroes and Deities*, a serious multiplayer OCCG designed to teach historical and mythological knowledge while accommodating ADHD-related needs through pacing, clarity, and feedback mechanisms.

The objectives of this research are:

1. to describe the design and implementation of an ADHD-inclusive educational card game;
2. to analyze the applied mechanics and difficulty adjustment strategies;
3. to evaluate the system using structured qualitative and usability metrics.

## LITERATURE REVIEW

Previous research emphasizes the effectiveness of serious games in education, particularly when gameplay mechanics are intrinsically aligned with learning objectives to prevent cognitive distraction (Escudeiro et al., 2025a). In this context, the training and certification of competencies through serious games

have proven to be a robust methodology for ensuring that educational goals are met within interactive environments (Baptista et al., 2024). For players with ADHD, studies indicate that turn-based systems and structured rule-based interactions are highly beneficial; these mechanics reduce time pressure and cognitive overload, thereby facilitating sustained focus.

In this context, Dynamic Difficulty Adjustment (DDA) remains a cornerstone for maintaining player engagement by balancing challenge with skill level. Passive DDA approaches, such as skill-based matchmaking using Elo-like systems, are generally preferred in competitive frameworks as they preserve the perception of fairness. Beyond difficulty scaling, the literature on inclusive game design highlights the necessity of clear user interfaces and reduced sensory clutter (Escudeiro et al., 2025b). Recent advancements in the field have demonstrated that “playing with a purpose” can revolutionize accessibility, using serious games as primary tools for social inclusion and the sustainability of educational practices (Escudeiro et al., 2025a; Escudeiro et al., 2008).

Moreover, fostering inclusivity requires creative approaches to game design, such as adapting mechanics to specific sensory or cognitive perceptions to ensure equitable participation (Escudeiro & Gouveia, 2024). While technologies like automatic translation and specialized interfaces have begun to bridge accessibility gaps in education (Escudeiro et al., 2025b), there remains a significant opportunity to explore the intersection of historical educational content, competitive multiplayer systems, and neurodiverse design. This project seeks to address this gap by integrating these elements into a unified framework for ADHD-accessible competitive gaming, contributing to the literature and future work in the field.

## METHODOLOGY

### HSI as a Supportive Framework for Design and Modelling

The development process was anchored in an Agile Scrum framework, characterized by weekly iterative sprints and a structured role-based organizational hierarchy. This approach allowed for rapid prototyping and continuous integration of feedback. Design decisions were rigorously informed by a three-fold framework: neurodiverse inclusivity guidelines (specifically for ADHD), pedagogical objectives regarding ancient civilizations, and competitive equilibrium requirements. This ensures integrative research is prioritized from the project's inception.

The architecture of *Ancient Dynasties* is a turn-based 1v1 OCCG. Players assume the role of mythological avatars, employing a deck-based strategy to deploy units, historical figures, and tactical maneuvers. Central to the gameplay is the “Blessings” resource management system, a deterministic mechanic designed to reduce cognitive load while maintaining strategic depth.

Regarding infrastructure, the hardware environment comprised high-performance workstations optimized for the Unity Engine, alongside Oculus Quest head-mounted displays for the development and empirical testing of the Augmented Reality (AR) module. The software stack was centered on Unity and C# via Visual Studio, complemented by a specialized design suite,

namely Figma for UI/UX prototyping, Adobe Illustrator for vector-based asset creation, and Blender for 3D modeling and spatial assets.

### **Core Mechanics**

To ensure high engagement and cognitive accessibility, the following key systems were engineered:

- **Incremental Resource Management (Blessings):** A capped, linear progression system that facilitates long-term strategic planning and minimizes the “analysis paralysis” often associated with complex resource tracking.
- **Fixed-size Deck Architecture:** By enforcing strict deck constraints, the game promotes a balanced meta-game and reduces the entry barrier for players with ADHD, focusing on quality of interactions over quantity of components.
- **Mythological Ability Implementation (Myth Powers):** Discrete, once-per-turn active abilities that reinforce the thematic educational content while providing clear tactical choices.
- **The Fatigue Mechanic:** A systematic penalty applied to players with depleted decks, functioning as a non-arbitrary game-ending condition that necessitates efficient resource allocation and prevents indefinite match stalling.

### **Dynamic Difficulty Adjustment**

The project utilizes a DDA system to maintain the “flow state” essential for educational retention. This is executed through a modified Elo rating model, where a player’s Matchmaking Ranking (MMR) is algorithmically adjusted based on win-loss ratios, opponent relative skill, and historical performance volatility.

Furthermore, the system supports Active Parameter Manipulation through a custom-game module. This allows for a “sandbox” approach to difficulty, where users or educators can manually calibrate core variables (such as initial health points or resource regeneration rates) to better suit specific learning paces or accessibility requirements.

### **Evaluation Framework**

The robustness of the game was assessed using a Quantitative Evaluation Framework (QEF) (Escudeiro & Bidarra, 2008), which provides a mathematical basis for measuring software quality across three critical dimensions:

1. **Functionality:** Assessing the technical stability and correct execution of game logic.
2. **Adaptability:** Measuring the system’s capacity to adjust to different player skill levels and neurodiverse profiles.
3. **Usability:** Evaluating the interface’s efficiency and user satisfaction.

To complement the QEF, the System Usability Scale (SUS) was administered. The interpretation of SUS scores was specifically calibrated to account for the ADHD demographic, prioritizing metrics such as “error prevention,” “visibility of system status,” and “minimalist design” to ensure that the interface does not act as a sensory or cognitive barrier to the educational content.

## **RESULTS**

This chapter presents the findings derived from the application of QEF (Escudeiro & Bidarra, 2008; Escudeiro & Escudeiro, 2012). This provides a comprehensive analytical lens through which fundamental software dimensions are examined using predefined metrics. This provides real-life feedback and strengthens the outcomes.

The evaluation demonstrated robust overall performance across all analyzed domains. The SUS yielded a score of 80%, which, according to standardized interpretation criteria, indicates a high level of usability. These data suggest that the design interventions - particularly regarding interface clarity, gameplay pacing, and immediate feedback mechanisms - were effective for the target ADHD demographic.

The aggregated QEF score reached 99%, reflecting near-total fulfillment of functional requirements, accessibility objectives, and system reliability. Educational content was perceived by users as organically integrated into the gameplay rather than intrusive. This equilibrium facilitated the maintenance of player flow and engagement without compromising the pedagogical components related to ancient civilizations.

Minor challenges were identified during the development lifecycle, primarily concerning internal team coordination and the partial implementation of advanced features. Notably, the full diversity of card effects and the robustness of the backend security infrastructure remain areas for future refinement. Notwithstanding these limitations, the evidence confirms that the adopted methodology ensured integrative research from the project’s inception, maintaining neurodiverse user needs as the central axis of technological development.

## **DISCUSSION**

The results of this study support the premise that CCGs serve as an effective structural framework for serious games, especially when integrated with inclusive design strategies. The high QEF score of 99% indicates that the core objective of the project (aligning educational content about ancient civilizations with engaging multiplayer mechanics) was successfully achieved. By employing the Unity engine and C# for development, as specified in the technical documentation, the system maintained high reliability across its functional requirements.

The implementation of passive DDA through a modified Elo matchmaking system has proven to be essential for balancing competitive fairness. This mechanism directly addressed one of the key features outlined in the Game

Design Document: providing a scalable challenge that accommodates both novice and experienced players. For the ADHD demographic, this balance is critical, as it prevents the frustration associated with excessive difficulty and the disengagement caused by insufficient challenge, thereby facilitating a state of flow.

The positive usability outcomes, reflected in the 80% SUS score, validate the specific ADHD-oriented design decisions. Elements such as the Blessing resource system and the structured turn-based mechanics reduced cognitive load and downtime. This confirms that a clear visual hierarchy and deterministic rulesets are vital for neurodiverse accessibility, allowing players to focus on strategic planning and educational content rather than being overwhelmed by sensory clutter or complex interface navigation.

However, some limitations must be acknowledged. As previously noted, the development faced challenges regarding full implementation of card effect diversity. The reliance on third-party backend services for multiplayer functionality and geolocation bonuses poses potential risks for long-term scalability and data security. Furthermore, while the current evaluation provides a strong foundation, the project would benefit from broader longitudinal testing. Despite these limitations, this research establishes a robust foundation for the integration of inclusive design and serious gaming, offering a scalable model for future educational tools tailored to neurodiverse populations.

To conclude, the results demonstrate positive feedback regarding methodology. Additionally, an integrative research approach from inception ensures that serious games can be both inclusive and educationally effective. The synergy between historical pedagogical objectives and modern CCG mechanics offers a promising pathway for inclusive educational technology.

## CONCLUSION

This paper presented the design, implementation, and evaluation of *Ancient Dynasties: Heroes and Deities*, an educational multiplayer card game specifically tailored for ADHD-inclusive gameplay. By integrating historical pedagogical content with competitive turn-based mechanics, the project successfully demonstrated that serious games can maintain a high level of engagement and fairness while fulfilling accessibility requirements. The high quality scores obtained through the QEF and SUS frameworks validate the methodology adopted and the inclusive design philosophy prioritized throughout the development lifecycle.

Therefore, this study serves as a valuable foundation for further innovation in the field of inclusive educational technology. Future work will focus on expanding gameplay depth through a greater diversity of card effects, improving the backend infrastructure for enhanced scalability, and refining the AR module via Oculus Quest. In addition, conducting longitudinal studies on learning outcomes will be essential to further quantify the long-term educational impact of the platform. Ultimately, *Ancient Dynasties* establishes a meaningful precedent for the design of competitive multiplayer

environments that are both educationally enriching and accessible to neurodiverse populations, ensuring equitable social participation.

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