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Integrating Game-Based Learning in Primary Education: The KIDEDU Project for Economics and Natural Sciences

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ABSTRACT

This paper presents KIDEDU (Play – Create – Learn), an educational game developed and launched at the University of Piraeus. The project aims to offer an engaging tool for primary school pupils to develop economical and geological (natural sciences) skills through play-based learning. Designed for all six grades of Greek primary education, KIDEDU represents an innovative teaching approach within the Greek educational system. It integrates Economics and Natural Sciences, encouraging pupils aged 6–12 to apply these concepts in everyday life through interactive and enjoyable activities.

The game-based methodology helps students learn in a fun, problem-solving environment. KIDEDU was piloted with pupils aged 8–10, followed by a questionnaire assessing their learning experience. The results indicated that pupils prefer play-based learning, find it easier and more enjoyable, and achieve deeper understanding through gameplay. The long-term goal is to expand KIDEDU across all educational levels, promoting game-based learning as a core teaching method.

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Introduction

In recent years, digital game-based learning (DGBL) has emerged as a powerful educational tool, transforming the traditional classroom into an interactive and engaging learning environment. The evolution of educational technology and the increased emphasis on differentiated and student-centered pedagogies have opened new avenues for innovation, particularly in primary education [1,2]. Within this context, the present paper introduces KIDEDU (Play – Create – Learn), a game-based teaching initiative developed at the University of Piraeus, aiming to enhance the learning experience of primary school pupils in the subjects of economics and natural sciences.

The KIDEDU project responds to the growing need for educational practices that resonate with the learning preferences of digitally native children aged 6–12. Pupils are not passive recipients of information but are encouraged to explore, create, and apply concepts through structured gameplay, thereby enhancing both cognitive engagement and intrinsic motivation [3].

The initial implementation of KIDEDU targeted pupils aged 8 to 10 and involved gameplay followed by a structured questionnaire. This aligns with contemporary research in digital pedagogy, which supports the integration of game mechanics to promote deeper learning and increased retention [4]. As a differentiated learning tool, KIDEDU allows pupils to progress at their own pace, adjust to their own cognitive needs, and actively construct knowledge-principles that are crucial in modern primary education.

This paper explores the theoretical underpinnings of the KIDEDU project, its instructional design, and the results of its pilot testing. It further proposes the expansion of this educational model across all levels of formal education, with the long-term vision of mainstreaming game-based learning as a primary pedagogical method in the Greek school system.

Literature Review

The integration of digital games into educational practice has seen significant growth, particularly in response to the changing learning preferences of 21st-century students. Digital Game-Based Learning (DGBL) has been defined not merely as the use of games in classrooms, but as the deliberate design of instructional environments where educational goals are embedded within gameplay mechanics [5]. The relevance of DGBL is particularly pronounced in subjects such as economics and natural sciences, where abstract or complex concepts can often appear disconnected

from learners' everyday experiences.

Digital environments allow learners to engage with simulations, problem-solving tasks, and interactive feedback that support experiential learning. Found that well-designed educational games improve cognitive, behavioral, and affective outcomes, especially when applied to STEM-related fields [6]. Moreover, such environments offer opportunities for contextualized learning, enabling children to understand the application of scientific and economical knowledge in real-world scenarios. In the context of natural sciences, this may involve exploring ecological systems, geological formations, or weather patterns through simulated interaction rather than rote memorization.

From a motivational perspective, research shows that digital games can lead to higher levels of engagement and perseverance, especially in STEM subjects where learners often struggle with abstraction or lack of context [7]. The motivational pull of DGBL is enhanced when learners feel a sense of control, progression, and relevance-factors that also characterize effective guided discovery environments. Teachers, therefore, play a crucial role not just as facilitators of gameplay, but as designers of learning experiences that align game content with curriculum goals.

In sum, the literature supports the strategic integration of DGBL and GDL, especially in economics and natural sciences. These approaches enable learners to experiment, explore, and construct meaning, while also accommodating diverse needs through differentiation. When appropriately designed, digital games can foster both engagement and deep learning, particularly when guided exploration is at the heart of the instructional strategy.

The KIDEDU Project exemplifies the integration of game-based learning (GBL) in primary education, particularly in economics and natural sciences, by leveraging the engaging nature of games to enhance student motivation and knowledge retention. Research indicates that GBL fosters active learning, critical thinking, and collaboration among students, aligning with curricular goals while accommodating diverse learning styles [8,9]. A systematic review highlights that GBL can effectively improve cognitive outcomes, although many studies focus on higher-grade students, suggesting a need for tailored approaches in primary education [10]. The PlayfulPeer Pedagogy Framework further supports this integration by combining GBL with peer learning, demonstrating positive impacts on communication and critical thinking skills. Despite the promising results, challenges such as limited access to technology and the need for teacher training remain significant barriers to widespread implementation [11]. Overall, the KIDEDU Project illustrates the potential of GBL to create engaging and effective learning experiences in primary education.

Theoretical Framework & Research Questions

The development of the KIDEDU platform is grounded in a combination of constructivist and socio-cognitive learning theories, drawing particularly on the principles of Digital Game-Based Learning (DGBL), Guided Discovery Learning (GDL), and Differentiated Instruction (DI). These frameworks support the creation of an educational experience that is engaging, learner-centered, and adaptable to the needs of diverse pupils within the primary school context.

At its core, KIDEDU aligns with socio-cultural theory, which emphasizes the importance of social interaction and scaffolding in the learning process [12]. According to Vygotsky, learners perform best when guided through their Zone of Proximal Development (ZPD)—the space between what they can do alone and what they can achieve with help. In KIDEDU, this guidance is built into both the game design and the instructional framework, where learners are encouraged to discover concepts through structured exploration and problem-solving. This is a clear expression of Guided Discovery Learning, where the teacher or system provides timely cues, hints, or challenges that help the student progress without direct instruction [13].

Simultaneously, DGBL introduces motivational and cognitive mechanisms that are supported by self-determination theory, which highlights autonomy, competence, and relatedness as key drivers of intrinsic motivation [14]. The game's mechanics are designed to support these elements: players make meaningful choices, experience adaptive challenges, and receive immediate feedback that fosters a sense of accomplishment and relevance. This creates a positive feedback loop that encourages repeated engagement and deeper conceptual understanding, particularly in subjects such as economics and natural sciences, where abstract thinking and conceptual transfer are required.

Research Questions

Based on the above objectives, the study addresses the following research questions:

- To what extent does the KIDEDU game enhance pupil motivation and engagement in economics and natural sciences?
- How do guided discovery elements within the game influence learners' conceptual understanding of scientific and economical content?
- What are pupils' perceptions of learning through game-based and differentiated approaches?
- Can the KIDEDU model be effectively expanded across different age groups and subject areas within primary education?

Methodology

The study was conducted in three Greek public primary schools, with a sample of approximately 200 pupils aged 8–10 years, corresponding to the third and fourth grades. The schools represented mixed socio-economic areas, and the student sample included pupils with varied academic abilities. Parental consent and school approvals were obtained, and participation was fully voluntary and anonymized.

This age group was chosen based on developmental appropriateness and cognitive readiness to engage with narrative-based tasks, logical puzzles, and scientific reasoning [15]. The diversity of the sample enabled the evaluation of how the game functioned within heterogeneous classrooms, particularly in terms of differentiated instruction.

The KIDEDU Game Environment

KIDEDU (Play - Create - Learn) is a 3D single-player educational game developed by a research team at the University of Piraeus. The game follows the narrative of a child sent to complete a grocery list, who is then interrupted by a wizard requesting help to break magical spells in exchange for the grocery items. The gameplay is structured around interactive mini-games and puzzles integrated into the storyline, each requiring players to apply concepts from economics and natural sciences.

To support differentiated learning, the game offers three difficulty tiers based on age and cognitive development (6–8, 8–10, and 10–12 years), with variations in the complexity of tasks and game

mechanics. This design allows adaptation to individual learner needs, offering both scaffolding and challenge, in line with inclusive instructional strategies.

Procedure and Implementation

The game was introduced during regular class time, and pupils played individually on computers or tablets. Teachers facilitated the technical setup but did not provide instructional intervention during gameplay, aligning with the principles of guided discovery learning and autonomous exploration [16]. Each child completed the game independently, without peer or teacher interference, to preserve the internal validity of the learning experience and isolate the game's effect on student engagement.

This setup mirrors the conditions of prior GBL research that emphasizes the balance between learner autonomy and embedded instructional guidance through game mechanics and feedback systems [17,18].

Figure 1: The Hero Counts his Money and gets the Shopping List

Figure 2: The Hero in the Forest

Post-Game Questionnaire

After completing the game, all pupils were asked to fill out a brief, anonymous questionnaire designed to assess:

- Their engagement during the game,
- Their perceptions of learning effectiveness, and
- Their preferences regarding instructional format (game-based vs. traditional teaching).

The questionnaire was based primarily on Likert-scale items (1 = strongly disagree to 5 = strongly agree) tailored for young learners, a method widely used for affective and perception-based data collection in primary education [19,20]. Items included statements such as "I enjoyed learning with the game," "I want to play more games like this," and "I understood maths/science better through the game."

The form also included optional open-ended questions for qualitative insights, which allowed pupils to describe what they enjoyed or struggled with. Questionnaire administration took 10–15 minutes, and clarifications were provided by teachers when needed, without leading responses.

Findings

Following the implementation of the KIDEDU game across three primary schools, a total of approximately 200 pupils aged 8–10 completed the game experience and participated in a post-intervention survey. The results suggest a strong positive reception of the digital game-based learning model, as well as indications of increased engagement and learning efficacy compared to traditional methods.

Research data was collected from both the questionnaires and the Contractor's personal notes. This data was analyzed and cross-referenced in order to provide evidence relating to the research questions. The most important findings per question are presented in this section.

The initial phase of this research showed that the questionnaire was reasonably well structured, with an average completion time of between 3 and 4 minutes. More specifically:

- Most of the kids were able to solve the problems of the game and complete the game with ease. Their participation was particularly active and intense, showing enthusiasm during the implementation of the activities. No particular problems

were observed in getting familiar with the game.

- Children's interaction with the application environment was highly engaging, with children quickly reaching high levels of practicality.
- The educational game encouraged pupils to develop various problem-solving strategies, act in a specific environment, control their actions and understand the consequences of their interaction with it, encouraging critical thinking.
- When solving the problems, the pupils either followed a specific plan of approach to the solution or flexibly adapted to the requirements of each activity.
- Pupils mainly preferred to work in pairs. One child helped and guided the other where this was deemed necessary, thus limiting the role of the teachers.
- The use of images and sound effects played an important role in engaging pupils with the educational game.

Of the 200 survey participants, 49% were boys and 51% were girls. The gender distribution among participants is relatively balanced, with slightly more girls than boys.

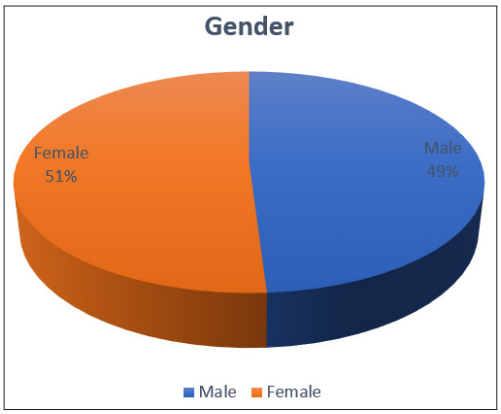

Figure 3: Gender of the Participants

All pupils aged 8-10 years (elementary school pupils).

94% (188 out of 200) of the children use a computer or tablet. The large majority of children use a computer or tablet, which shows their familiarity with technology and their ability to effectively interact with the game application.

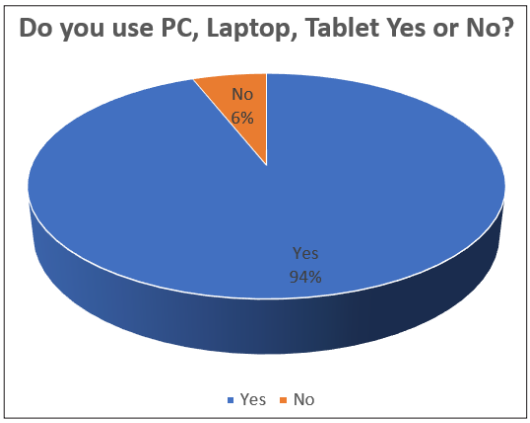

Figure 4: Use of Technology

The following questions are related to the Game Experience: The children's experience during the operation of the game application was assessed through quantitative analysis of the respective responses. The results collected are detailed below:

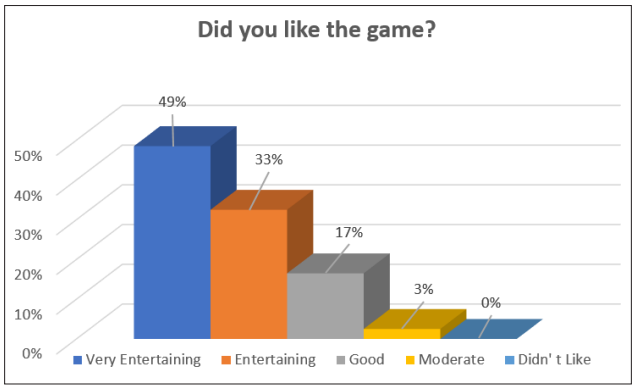

Figure 5: Game Fun

82% of children rated the game as fun or very fun.

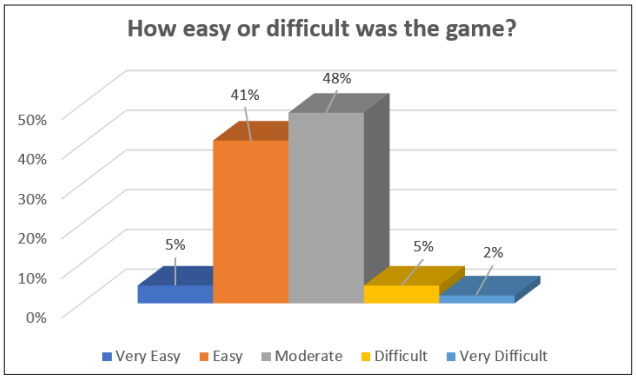

Figure 6: Game Difficulty

93% of children found the game very easy, easy of moderate.

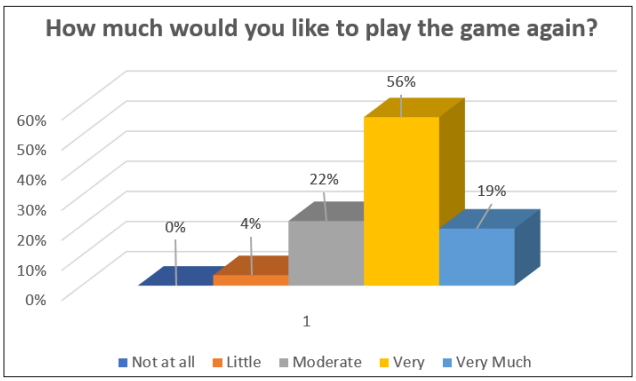

Figure 7: Willingness to Replay

75% of the participants (very and very much) answered that they want to play the game again.

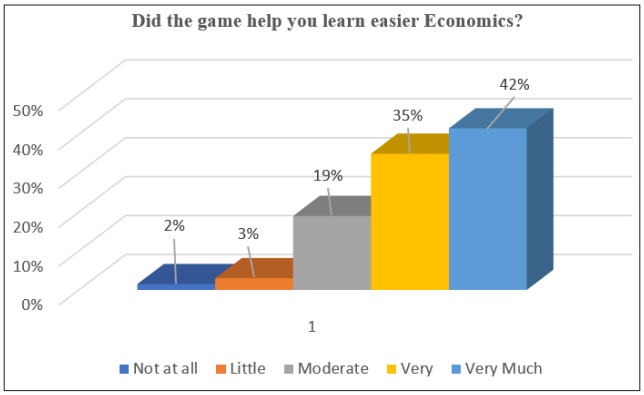

Figure 8: Easier Learning Economics

77% of children answered that they learned Economics easier or much easier playing the game.

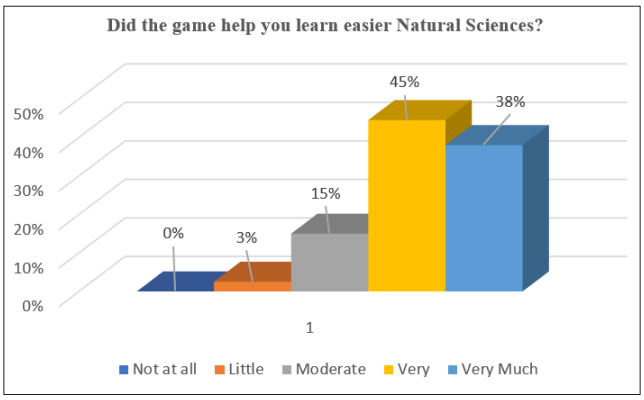

Figure 9: Easier Learning Natural Sciences

83% of children answered that they learned Natural Sciences easier or much easier playing the game.

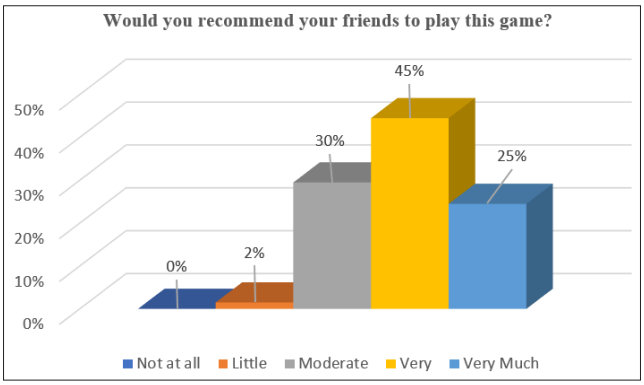

Figure 10: Recommendation of the Game

70% of the participants will recommend (very and very much) the game to their friends.

Discussion

The outcomes of the KIDEDU intervention reinforce the pedagogical value of integrating digital game-based learning (DGBL) with guided discovery and differentiated instruction. The game's ability to maintain pupil attention, promote deep engagement, and foster conceptual learning in economics and natural sciences suggests that such tools can play a transformative role in contemporary education.

A central feature of the game was its narrative-driven structure, which appears to have significantly contributed to learner engagement. As noted by embedding educational content in compelling narrative contexts enhances immersion and allows learners to develop identity and purpose within the learning environment [21]. In the case of KIDEDU, the quest-based storyline and the inclusion of fantastical characters (e.g., the wizard) created a meaningful context for learners to solve problems and apply their knowledge.

Interactive digital environments that involve exploratory play and challenge-based learning have been shown to enhance intrinsic motivation [22,23]. Pupils in this study responded positively to the challenges and autonomy the game offered, which aligns with the broader literature linking autonomy-supportive environments to increased cognitive engagement and learning outcomes [24].

While the game did not involve direct instruction, its design embedded structured problem-solving elements, offering scaffolded support without removing learner agency. Argue that minimally guided instruction often leads to cognitive overload; however, when digital environments are carefully designed to include embedded guidance, learners are supported through productive struggle—a core tenet of guided discovery learning [25].

In the KIDEDU game, mini-games and puzzles required pupils to apply logical reasoning and basic science concepts in interactive ways. This method reflects what describe as "learning through discovery simulations", where learners benefit from rich, hands-on tasks that are constrained and structured to support conceptual understanding [26].

The inclusion of age-based content levels (6–8, 8–10, 10–12) enabled the game to address varying developmental needs and prior knowledge. As Carolan and Guinn (2007) suggest, differentiation in digital learning tools can be achieved through adaptive content delivery and tiered complexity. KIDEDU applied this principle by varying game mechanics and question difficulty, allowing pupils to interact with materials appropriate to their zone of proximal development.

This flexibility is especially important in heterogeneous classroom settings, where standardized instruction often fails to meet diverse learning needs. Digital games, when well-designed, can offer non-stigmatizing differentiation, where learners are not visibly grouped or labelled, but simply experience tailored levels of challenge within the same environment [27].

The positive feedback from pupils in this pilot implementation suggests a potential pathway for expanding such tools into broader curriculum use. However, for sustainable integration, educator training and curricular alignment are crucial. As warns, educational games risk becoming isolated experiences unless embedded within pedagogical frameworks and accompanied by reflective activities [28].

Furthermore, although this study focused on short-term pupil perceptions and in-game performance, long-term impact studies are needed. Particularly, mixed-method approaches that combine gameplay analytics with learning outcomes and behavioral observations could provide deeper insights [39].

Conclusion

This project contributes to a growing body of research that views learning as an active, constructivist process, where children build knowledge through interaction, play, and guided exploration [30]. By situating tasks within a meaningful context (e.g., a magical quest), learners were able to apply abstract concepts to simulated real-world situations—an approach known to foster transferable knowledge [31].

A key takeaway from the pilot study is the game's capacity to support differentiated learning without compromising inclusivity. Pupils of varying skill levels were able to access the content at an appropriate level of challenge, without the stigma often associated with differentiated instruction in traditional classroom settings. The inclusion of in-game scoring and feedback further supported formative assessment practices, helping learners monitor their progress and build self-efficacy [32].

Although promising, the study also highlights the need for systemic support in integrating such tools into mainstream education. Future work must examine not only pupil performance but also teacher readiness, curriculum alignment, and long-term learning outcomes. As highlighted by Sandford, the success of DGBL depends not only on the design of the game itself but on the broader ecosystem in which it is implemented [33,34].

In sum, KIDEDU demonstrates that playful learning environments, when grounded in sound pedagogy and thoughtful design, can enrich the educational experience and bridge the gap between formal curricula and the digital lives of today's learners. Moving forward, interdisciplinary collaboration between educators, designers, and policymakers will be essential to unlock the full potential of such innovations.

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