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Digital Innovation and Learning: Serious Games and ICT as Tools for Educational Engagement

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Abstract

Digital innovation has brought about substantial changes in the contemporary educational landscape, accelerating the transition from traditional, teacher-centered models to interactive and student-centered approaches. Information and Communication Technologies (ICT) play a decisive role in creating dynamic learning environments that promote active student participation and strengthen the knowledge-building process. Within this evolving context, serious games have emerged as particularly promising tools that harness gamification mechanisms to enrich the learning experience. Through their application, students' cognitive, emotional, and behavioral engagement is reinforced. This article explores the role of serious games and ICT as instruments of educational engagement, examining both their pedagogical potential and the challenges associated with their integration into contemporary educational practice.

Keywords: Digital Innovation; Information and Communication Technologies (ICT); Serious Games; Educational Engagement; Student-Centered Learning; Gamification; Digital Education; Active Learning; Interactive Teaching; Educational Technology

1. Introduction

Digital innovation has brought about profound changes in the modern educational environment, transforming both instructional practices and students' learning experiences. The integration of Information and Communication Technologies (ICT) has evolved beyond a merely supportive function to become a central pillar in the redesign of education toward more flexible, interactive, and student-centered learning models (Bond et al., 2020; Cabero-Almenara et al., 2021; European Commission, 2020; OECD, 2019; Redecker, 2017; Selwyn, 2016; Voogt et al., 2018). Within this context, the use of digital tools is closely linked to the cultivation of 21st-century competencies, including critical thinking, collaboration, and digital literacy. Students are increasingly expected to function as active knowledge constructors rather than passive recipients, which necessitates the adoption of pedagogical approaches that enhance their participation and engagement (Falloon, 2020; Fullan and Langworthy, 2014; Ilomäki et al., 2016; Mishra and Koehler, 2006; Scott, 2015; Trilling and Fadel, 2009). The growing body of empirical evidence underscores the capacity of ICT to transform educational practices and strengthen student engagement across diverse learning environments (Bardis et al., 2010; Chaidi et al., 2021; Drigas and Theodorou, 2016; Moraiti et al., 2022; Simos and Karabatzaki, 2025; Simos et al., 2026a; Kefalis et al., 2025; Politi et al., 2020).

Student engagement is a critical determinant of learning effectiveness. This multidimensional construct encompasses cognitive, emotional, and behavioral dimensions, each of which directly influences academic performance and

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knowledge retention (Bond et al., 2020; Fredricks et al., 2016; Henrie et al., 2015; Kahu, 2013; Reschly and Christenson, 2012; Sinatra et al., 2015). Against this backdrop, serious games have emerged as innovative educational tools that integrate learning content with game-based elements such as challenge, feedback, narrative, and reward systems. Through these mechanisms, experiential and engaging learning environments are created that foster active participation and facilitate deeper understanding of subject matter (Boyle et al., 2016; Connolly et al., 2012; Deterding et al., 2011; Plass et al., 2015; Wouters et al., 2013). The pedagogical value of serious games is further illuminated by self-determination theory, which posits that the satisfaction of basic psychological needs, namely autonomy, competence, and relatedness, strengthens intrinsic motivation (Deci and Ryan, 2000; Mekler et al., 2017; Ryan and Deci, 2017; Sailer et al., 2017; Xi and Hamari, 2019; Drigas et al, 2023).

Concurrently, ICT and serious games offer valuable opportunities for instructional differentiation and adaptation to the diverse needs of learners, particularly within inclusive education settings. Their use has been associated with increased engagement, improved learning outcomes, and enhanced student self-efficacy (Clark et al., 2016; Huang et al., 2020; Schindler et al., 2017; Tokac et al., 2019; Zainuddin et al., 2020). Nevertheless, the integration of digital tools into educational practice is accompanied by notable challenges, including insufficient teacher training, technological inequalities, and the imperative for pedagogically grounded application of digital media (Ertmer and Ottenbreit-Leftwich, 2019; Instefjord and Munthe, 2017; Petko, 2020; Tondeur et al., 2017).

2. Methodology

This study employs a systematic literature review to examine the role of ICT and serious games in enhancing student engagement. The literature search was conducted across major academic databases, including Scopus, Web of Science, and Google Scholar, focusing on peer-reviewed articles published between 2016 and 2026. This timeframe was selected to capture the rapid evolution of digital technologies, gamification practices, and artificial intelligence in education over the past decade. The search strategy employed keywords such as “ICT in education,” “serious games,” “gamification,” and “student engagement.” Inclusion criteria required that studies examine the use of digital technologies in educational contexts and address at least one dimension of student engagement (cognitive, emotional, or behavioral). Non-peer-reviewed sources and studies unrelated to educational settings were excluded.

The selection process followed three stages: identification, screening, and eligibility assessment through full-text analysis. The final corpus of studies was analyzed using a thematic analysis approach, focusing on recurring patterns related to types of digital tools, dimensions of engagement, learning outcomes, and pedagogical conditions for effective implementation. This methodological framework ensures a structured and comprehensive synthesis of the existing literature, enabling the extraction of meaningful conclusions regarding the benefits, challenges, and future directions of ICT and serious games in education.

Research Questions

The study is guided by the following research questions:

- RQ1: How do ICT tools and serious games influence student engagement in educational settings?
- RQ2: What are the cognitive, emotional, and behavioral dimensions of engagement enhanced through the use of digital technologies?
- RQ3: What pedagogical factors contribute to the effective integration of serious games and ICT in teaching?
- RQ4: What challenges and limitations are associated with the use of gamification and digital tools in education?

3. Theoretical Framework: Digital Learning and Educational Engagement

3.1. Digital Learning and ICT in Contemporary Education

Digital learning constitutes one of the cornerstones of contemporary educational theory and practice, as it is inextricably linked to the deployment of ICT to support teaching and learning. ICT enables the creation of dynamic, multimodal learning environments in which students interact with content, educators, and peers in ways that transcend the boundaries of conventional instruction (European Commission, 2020; OECD, 2019; Redecker, 2017; Selwyn, 2016; Voogt et al., 2018). The integration of ICT into education extends beyond the mere utilization of digital tools to encompass the fundamental redesign of pedagogical approaches. Theoretical frameworks such as TPACK (Technological Pedagogical Content Knowledge) and SAMR (Substitution, Augmentation, Modification, Redefinition) underscore the importance of integrating technology, pedagogy, and content knowledge to achieve meaningful learning outcomes (Falloon, 2020; Mishra and Koehler, 2006; Petko, 2020; Puentedura, 2014; Tondeur et al., 2017).

Digital learning also contributes to the differentiation of instruction, enabling the adaptation of content, pace, and activities to meet individual student needs. Such personalization fosters self-regulated learning and promotes the development of metacognitive skills that are essential for lifelong learning (Huang et al., 2020; Ilomäki et al., 2016; Schindler et al., 2017; Zainuddin et al., 2020). Moreover, ICT has been extensively applied in both general and special education, contributing to the development of inclusive, student-centered learning environments (Bardis et al., 2017; Chaidi et al., 2021; Drigas and Theodorou, 2016; Moraiti et al., 2022; Simos, 2025a; Simos, 2025b; Simos and Katsiampoura, 2025).

3.2. Educational engagement: concept and dimensions

Student engagement is a foundational concept in contemporary pedagogy, as it is directly associated with the quality of the learning experience and its outcomes. It is a multidimensional construct that encompasses cognitive, emotional, and behavioral facets of student participation (Bond et al., 2020; Fredricks et al., 2016; Henrie et al., 2015; Kahu, 2013; Sinatra et al., 2015). Cognitive engagement refers to the intellectual effort and strategic investment students direct toward understanding subject matter. Emotional engagement encompasses the affective responses students experience, such as interest, enjoyment, or frustration. Behavioral engagement pertains to observable participation in learning activities and adherence to institutional norms (Appleton et al., 2008; Reschly and Christenson, 2012; Skinner et al., 2009).

Enhancing educational engagement is a primary objective of modern educational systems, as it is associated with reduced dropout rates and improved academic performance (Fredricks et al., 2016; Zepke, 2018). The deployment of ICT and digital tools can serve as a catalyst in this endeavor, generating learning environments that amplify students' active participation and sustain their interest (Bond et al., 2020; Henrie et al., 2015; Schindler et al., 2017). A growing body of research confirms that digital technologies play a pivotal role in strengthening students' emotional, cognitive, and social engagement (Chaidi and Drigas, 2022; Drigas and Sideraki, 2021; Mitsea et al., 2023; Simos, 2025c; Simos and Xyloparkioti, 2025; Simos et al., 2026b; Stathakis et al., 2024).

3.3. Serious games and learning theories

Serious games represent an innovative pedagogical approach that integrates game elements into educational environments to enhance learning. Their effectiveness is theoretically grounded in several established frameworks, including constructivism, experiential learning theory, and self-determination theory (Boyle et al., 2016; Connolly et al., 2012; Deterding et al., 2011; Dicheva et al., 2015; Plass et al., 2015; Sitzmann, 2011). According to constructivist principles, learners construct knowledge through active participation and interaction with their environment. Serious games provide rich opportunities for such engagement, as they enable students to experiment, make decisions, and experience the consequences of their choices within a safe, controlled setting (Clark et al., 2016; Gee, 2003; Wouters et al., 2013).

Self-determination theory further elucidates the motivational affordances of serious games, positing that intrinsic motivation is enhanced when basic psychological needs for autonomy, competence, and relatedness are satisfied. Through mechanisms such as progressive challenge, immediate feedback, and visible progress indicators, serious games contribute to the fulfillment of these needs and thereby strengthen learning engagement (Mekler et al., 2017; Ryan and Deci, 2017; Sailer et al., 2017; Xi and Hamari, 2019). The use of serious games has been associated with improved learning outcomes, particularly when implemented within pedagogically informed instructional designs. However, their effectiveness is contingent upon the method of integration, the quality of game design, and the degree of teacher facilitation (Boyle et al., 2016; Clark et al., 2016; Tokac et al., 2019; Zainuddin et al., 2020). Emerging technologies, including artificial intelligence, robotics, and interactive systems, further augment the educational potential of serious games (Moraiti et al., 2022; Pergantis and Drigas, 2024; Pergantis et al., 2025).

4. Serious Games in Educational Practice

4.1. Pedagogical Use of Serious Games

Serious games are among the most dynamic instruments in contemporary educational technology, combining learning with experiential interaction and a hands-on approach to knowledge construction. Their pedagogical value resides in their capacity to create authentic learning environments in which students actively participate and build knowledge through action and reflection (Boyle et al., 2016; Cheng et al., 2015; Clark et al., 2016; Connolly et al., 2012; Papastergiou, 2009; Plass et al., 2015; Wouters et al., 2013).

The integration of serious games into teaching promotes active learning by requiring students to make decisions, solve problems, and exercise strategic thinking. These processes cultivate critical thinking, creativity, and collaborative competencies (Deterding et al., 2011; Gee, 2003; Hamari et al., 2016; Sailer et al., 2017; Tokac et al., 2019). A further advantage of serious games is their provision of immediate feedback, which is widely recognized as a critical factor in effective learning. By continuously informing students of their progress, such feedback mechanisms enhance self-regulation and learning confidence while sustaining high levels of engagement (Clark et al., 2016; Hattie, 2009; Schindler et al., 2017; Zainuddin et al., 2020). Research has further demonstrated that the pedagogical integration of serious games supports the development of higher-order thinking skills, including problem-solving and critical analysis (Moraiti et al., 2022; Pergantis and Drigas, 2024; Pergantis et al., 2025).

4.2. Serious games and learning outcomes

The contribution of serious games to learning outcomes has been the subject of extensive empirical investigation. Numerous studies demonstrate that their use can lead to improved comprehension, enhanced memory retention, and more effective application of knowledge, particularly when combined with sound instructional design (Boyle et al., 2016; Clark et al., 2016; Huang et al., 2020; Sitzmann, 2011; Tokac et al., 2019; Wouters et al., 2013).

Serious games appear to be particularly effective in cognitively demanding subjects that require problem-solving and the development of higher-order skills. The interactivity and simulation of real-world scenarios enable students to apply knowledge in authentic contexts, thereby facilitating the transfer of learning (Connolly et al., 2012; Hamari et al., 2016; Plass et al., 2015; Zainuddin et al., 2020). Simultaneously, serious games contribute to improving students' attitudes toward learning by increasing interest and willingness to participate. The emotional engagement they generate is directly associated with higher levels of academic performance and knowledge retention (Deterding et al., 2011; Mekler et al., 2017; Sailer et al., 2017; Xi and Hamari, 2019).

4.3. Serious Games in Inclusive Education

The application of serious games is of particular significance within inclusive education, as it provides opportunities for instructional differentiation and adaptation to the diverse needs of all learners. Through digital games, students with varying learning profiles can actively engage in shared learning activities and experience meaningful participation (Huang et al., 2020; Schindler et al., 2017; Zainuddin et al., 2020).

For students with learning difficulties or neurodevelopmental conditions, serious games can function as supportive tools that enhance attention, memory, and social interaction. The incorporation of audiovisual elements and interactive mechanisms assists in maintaining concentration and reducing anxiety (Clark et al., 2016; Plass et al., 2015; Tokac et al., 2019). However, the successful integration of serious games into inclusive education necessitates careful planning and pedagogical guidance. The role of the educator remains paramount, as teachers must select appropriate tools and embed them within a coherent instructional framework that addresses students' individual needs (Ertmer and Ottenbreit-Leftwich, 2019; Petko, 2020; Tondeur et al., 2017). Empirical evidence further supports the role of digital technologies and serious games in fostering participation and social interaction among students with diverse learning needs in inclusive settings (Chaidi et al., 2021; Drigas and Sideraki, 2021; Mitsea et al., 2022; Simos, 2025d; Simos, 2026; Simos et al., 2025).

5. ICT and Educational Engagement: Applications and Strategies

5.1. Digital Tools and Active Learning

The application of ICT in teaching has been closely associated with the promotion of active learning, as it facilitates the transition from passive knowledge transmission to dynamic, participatory learning environments. Digital tools, including interactive platforms, collaborative learning systems, and multimedia applications, create meaningful opportunities for student engagement in the learning process (Bond et al., 2020; Huang et al., 2020; Redecker, 2017; Zainuddin et al., 2020).

Digital tools foster student autonomy by enabling learners to explore, experiment, and construct knowledge through interaction. This approach aligns with the principles of active learning, which position the student at the center of the educational process as an active participant in knowledge construction (Falloon, 2020; Freeman et al., 2014; Prince, 2004; Schindler et al., 2017). Moreover, digital tools provide immediate feedback, which is a critical determinant of learning improvement. Continuous progress monitoring enhances self-regulated learning and sustains high levels of engagement (Clark et al., 2016; Hattie, 2009; Nicol and Macfarlane-Dick, 2006; Zepke, 2018). Empirical studies further confirm that ICT-based interventions significantly improve student motivation and active participation across varied

educational contexts (Bardis et al., 2009; Chaidi and Drigas, 2022; Drigas and Theodorou, 2016; Mitsea et al., 2023; Simos and Fountoulakis, 2026; Simos et al., 2026a).

5.2. Gamification and Learning Motivation

Gamification is a contemporary pedagogical strategy that incorporates game elements into non-game contexts to enhance student engagement and motivation. Elements such as points, levels, badges, and leaderboards contribute to the creation of stimulating learning environments (Deterding et al., 2011; Dicheva et al., 2015; Faiella and Ricciardi, 2015; Hamari et al., 2014; Mekler et al., 2017; Sailer et al., 2017).

Gamification primarily enhances students' intrinsic motivation by creating conditions of challenge, accomplishment, and recognition. Its connection to self-determination theory highlights the significance of satisfying basic psychological needs for autonomy, competence, and relatedness (Ryan and Deci, 2017; Sailer and Homner, 2020; Xi and Hamari, 2019). However, the effectiveness of gamification is contingent upon thoughtful pedagogical design and its purposeful integration into instruction. An excessive emphasis on extrinsic motivators risks undermining meaningful learning if not accompanied by substantive learning activities (Buckley and Doyle, 2017; Hanus and Fox, 2015; Kapp, 2012; Landers, 2014; Seaborn and Fels, 2015).

5.3. Digital Learning and Differentiated Instruction

Differentiated instruction is a foundational principle of modern education, closely linked to the adaptation of teaching to students' diverse needs, interests, and abilities. ICT offers considerable opportunities for implementing differentiation strategies, enabling the personalization of learning experiences (Hall et al., 2015; Ilomäki et al., 2016; Tomlinson, 2014; Zainuddin et al., 2020).

Through digital tools, educators can adjust content, activities, and instructional pace to accommodate diverse learning requirements. Such personalization enhances learning engagement and contributes to improved outcomes (Bond et al., 2020; Huang et al., 2020; Schindler et al., 2017). Of particular importance is the use of ICT in inclusive education, where differentiation constitutes a necessary precondition for the equitable participation of all students. Digital learning environments can support learners with varying profiles by offering multiple pathways for access, participation, and achievement (Al-Azawei et al., 2016; Florian and Black-Hawkins, 2011; Meyer et al., 2014; Rose and Dalton, 2009).

6. Challenges, Limitations, and Prospects of Digital Learning and Serious Games

6.1. Technological and Pedagogical Challenges

Despite the considerable advantages of integrating ICT and serious games into education, their implementation is accompanied by significant challenges of both a technological and a pedagogical nature. Unequal access to digital infrastructure, commonly referred to as the "digital divide," remains a persistent obstacle to the equitable deployment of technologies in education (European Commission, 2020; OECD, 2019; Selwyn, 2016; van Dijk, 2020). The effective integration of ICT further requires the development of both digital competencies and pedagogical knowledge among educators. Insufficient training frequently results in the superficial adoption of technologies without meaningful pedagogical impact (Ertmer and Ottenbreit-Leftwich, 2019; Instefjord and Munthe, 2017; Petko, 2020; Tondeur et al., 2017).

The integration of serious games similarly demands careful planning and alignment with clearly articulated learning objectives. Their deployment without a coherent pedagogical rationale may lead to superficial learning or student disengagement (Boyle et al., 2016; Clark et al., 2016; Connolly et al., 2012; Plass et al., 2015). Researchers have also noted challenges related to emotional regulation, cognitive load management, and the effective utilization of ICT in educational contexts (Chaidi et al., 2021; Drigas and Sideraki, 2021; Mitsea et al., 2023).

Limitations of Gamification and Digital Tools

Gamification and digital tools, notwithstanding their positive contributions, also present notable limitations. A primary concern relates to the risk of excessive reliance on extrinsic motivators, such as rewards and points, which may diminish students' intrinsic motivation over time (Deci and Ryan, 2000; Hanus and Fox, 2015; Mekler et al., 2017; Ryan and Deci, 2017). Prolonged exposure to digital environments may also engender cognitive fatigue, distraction, and the superficial processing of information, with students attending more to form than to content, thereby undermining deep learning (Kirschner and De Bruyckere, 2017; Mayer, 2014; Sweller et al., 2019).

Additionally, the quality of digital educational tools and serious games is not uniformly assured. The absence of scientifically rigorous design can compromise their effectiveness, underscoring the necessity for systematic evaluation and selection based on established pedagogical criteria (Boyle et al., 2016; Clark et al., 2016; Tokac et al., 2019; Zainuddin et al., 2020).

Future Prospects and Educational Directions

The prospects for digital learning and serious games in education are encouraging, as ongoing technological advancements continue to generate novel opportunities for teaching and learning. The integration of emerging technologies, including artificial intelligence, augmented reality, and virtual reality, is anticipated to further enhance the interactivity and personalization of educational experiences (Huang et al., 2020; Luckin et al., 2016; Makransky and Petersen, 2019; Radianti et al., 2020; Simos and Katsinis, 2026; Simos et al., 2026c).

Concurrently, the development of adaptive learning systems enables the creation of individualized learning pathways that respond dynamically to students' needs and performance trajectories. This approach holds significant promise for enhancing learning engagement and promoting instructional effectiveness (Bond et al., 2020; Holmes et al., 2019; Zawacki-Richter et al., 2019). Ultimately, the future deployment of serious games and ICT demands a holistic approach that integrates technology with sound pedagogy and coherent educational policy. Their successful implementation requires sustained investment in digital infrastructure, comprehensive teacher professional development, and the creation of high-quality, evidence-based digital content (European Commission, 2020; Klopfer et al., 2009; OECD, 2019; Redecker, 2017).

7. Conclusion

This systematic review has examined the role of ICT and serious games as instruments for enhancing student engagement across cognitive, emotional, and behavioral dimensions. The evidence synthesized across the reviewed literature indicates that, when integrated within pedagogically sound frameworks, serious games and ICT tools can significantly strengthen active participation, intrinsic motivation, and deeper learning. Their capacity to create immersive, interactive, and adaptive learning environments positions them as valuable complements to traditional instructional methods.

Nevertheless, the realization of their full educational potential is contingent upon several critical factors, including adequate teacher professional development, equitable access to digital infrastructure, and the adoption of evidence-based design principles for digital tools and game-based applications. The risks of over-reliance on extrinsic motivators and the challenges of cognitive overload in technology-rich environments merit continued scholarly attention.

Future research should prioritize longitudinal studies that track the sustained impact of serious games and ICT on student engagement and academic achievement. Moreover, the integration of emerging technologies such as artificial intelligence and immersive reality systems warrants further investigation, particularly regarding their capacity to personalize learning and accommodate diverse learner needs. A collaborative, interdisciplinary approach involving educators, technologists, and policymakers will be essential to harness the transformative potential of digital innovation in education.

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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