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Editorial

Game-Based Learning, Gamification and Serious Games: Advances, Gaps and a Research Agenda in the Age of Artificial Intelligence

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Abstract

Games have become one of the most powerful cultural and technological media of our time, and their use for purposes beyond entertainment, through game-based learning, gamification and serious games, has matured into an established field of research and practice. At the same time, the rapid diffusion of artificial intelligence (AI), and of generative AI and large language models in particular, is reshaping how learning games are designed, personalised, assessed and deployed. This Editorial introduces the Special Issue "Advances in Game-Based Learning, Gamification in Education and Serious Games" of Computers, which brings together thirteen contributions spanning bibliometric and systematic reviews, machine-learning-driven accessible games, game-based screening of dyslexia risk, adaptive interventions, virtual reality and tangible serious games, and gamified learning designs in school, higher, medical and teacher education, as well as in rehabilitation and health literacy. We situate these contributions within recent developments in the field, identify the main gaps in current knowledge, most notably the scarcity of rigorous and longitudinal evidence, the tension between engagement and learning, and the ethical and regulatory implications of AI-enabled games. We conclude by proposing a research agenda for AI-enhanced game-based learning, centred on theory-driven adaptivity, trustworthy learner modelling and stealth assessment, generative content and conversational agents with pedagogical guardrails, inclusion and accessibility, and robust evaluation.

Keywords: game-based learning; gamification; serious games; artificial intelligence; generative AI; large language models; adaptive learning; learning analytics; stealth assessment; extended reality

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1. Introduction

Video games are now one of the predominant forms of entertainment and a significant driver of social and cultural life. In a previous Editorial, we framed this phenomenon within the broader "ludification of culture" and argued that the motivational and

immersive qualities of games, the structured, rule-based dimension of *Ludus*, as well as the open, creative dimension of *Paidia* can be purposefully harnessed for learning, health, social awareness and behaviour change [1]. Serious games, game-based learning and gamification, understood as the use of game design elements in non-game contexts [2], have since become mainstream topics in educational technology, supported by the capacity of games to generate deep mental involvement or immersion [3].

Over the last decade, the evidence base has also matured. Meta-analyses have shown that well-designed digital games can improve learning outcomes when compared with non-game conditions [4,5], and that gamification produces small-to-medium positive effects on cognitive, motivational and behavioural learning outcomes, moderated by design choices such as the inclusion of game fiction and social interaction [6]. Recent bibliometric work confirms that the field is moving from early studies centred on motivation and engagement towards adaptive, personalised and domain-specific applications (Contribution 1).

The most significant shift in the field, however, is being driven by artificial intelligence (AI). AI has always been intertwined with games, from non-player character (NPC) behaviour to procedural content generation and player modelling [7]. In serious games, AI components for adaptation, emotion recognition, natural language processing and performance assessment have been developed as reusable building blocks [8], and data-driven player modelling has become a mature research area [9]. Stealth assessment, the unobtrusive, evidence-based inference of competencies from in-game behaviour, illustrates how games can become not only learning environments but also powerful assessment instruments [10]. These developments are part of a broader expansion of AI in education, whose promise has long been accompanied by calls for stronger pedagogical grounding and critical reflection [11].

Since 2022, generative AI and large language models (LLMs) have added a new layer to this landscape. LLMs can act as game designers, narrative engines, dialogue partners, game masters, players and assistants [12]; they can support virtually every phase of the serious game development lifecycle, from ideation and content production to user feedback and evaluation [13]; and they can power conversational tutors and adaptive scaffolding inside learning games. A recent systematic review of AI-supported game-based learning found generally positive effects on knowledge, motivation and engagement, but also highlighted that only a small fraction of studies were of high methodological quality and that effectiveness depends more on the alignment of AI mechanisms with learning theory than on algorithmic sophistication [14]. Evidence from outside games points in the same direction: a carefully designed AI tutor grounded in pedagogical best practices outperformed in-class active learning in a randomised controlled trial [15], whereas unrestricted access to a general-purpose generative AI assistant improved performance during practice but harmed subsequent learning when it was removed [16]. In other words, AI does not make learning games effective by itself—design does.

This shift also has regulatory and ethical implications. The European Union's Artificial Intelligence Act classifies several AI systems used in education and vocational training, such as those used to evaluate learning outcomes or to steer the learning process, as high-risk [17], while UNESCO has called for a human-centred approach to generative AI in education that protects learner agency, privacy and inclusion [18]. Learning games that model players, adapt content and assess competencies with AI therefore fall squarely within these concerns, and the community needs shared frameworks for the ethics of AI in education [19].

It is against this backdrop that we launched the Special Issue "Advances in Game-Based Learning, Gamification in Education and Serious Games" in Computers. The call invited contributions on the design, development, deployment and evaluation of games

and gamified systems for education, health, training, civic participation and social change, with explicit attention to virtual, augmented and extended reality, AI in serious games, the evaluation of impact, player motivation and immersion, multiplayer and community games, and ethics and privacy. In the following sections, we identify the main knowledge gaps in the field (Section 2), summarise the thirteen contributions published in the Special Issue and show how they address these gaps (Section 3), and propose directions for future research (Section 4).

2. Gaps in Current Knowledge

Despite the maturity of the field, several gaps remain, and many of them are amplified by the arrival of AI. We highlight six.

Rigour and duration of the evidence. Much of the empirical work on serious games and gamification still relies on small samples, single-group pre–post designs, self-reported measures and short interventions. The near absence of longitudinal studies, already noted in meta-analyses [4,6], remains one of the main limitations of AI-supported game-based learning [14].

The engagement–learning gap. Engagement and enjoyment are frequently used as proxies for learning, but the two do not necessarily coincide. Understanding which game elements, and which forms of instructional support around games, translate engagement into durable learning remains an open question.

Theory-driven adaptivity. Adaptive difficulty, personalised feedback and learner modelling are increasingly feasible, but adaptation is often driven by what the algorithm can do rather than by explicit pedagogical models. How adaptation should be directed, by whom (learner, teacher, system) and with what transparency remains insufficiently studied [14].

Inclusion and accessibility. Learners with sensory, motor or intellectual disabilities and neurodivergent learners remain under-represented in game-based learning research, even though AI-driven recognition and adaptation technologies open new opportunities for accessible play.

Cost and scalability of development. Serious games remain expensive to design, produce, localise and maintain, which limits their adoption and sustainability. Generative AI may lower these barriers [13], but its impact on quality, validity and authorship is still poorly understood.

Ethics, privacy and regulation. AI-enabled games collect fine-grained behavioural and, increasingly, biometric data, often from minors or vulnerable users. Bias in learner models, the opacity of automated assessment, the risk of over-reliance on AI assistance [16] and compliance with emerging regulation [17] are still rarely addressed in empirical studies.

3. Contributions of This Special Issue

The thirteen papers published in this Special Issue cover a wide range of purposes, target groups, technologies and application domains, from primary and higher education to medical and teacher education, rehabilitation, health literacy and online multiplayer communities. Table 1 provides an overview of the contributions, highlighting the role played by AI, data and adaptivity in each of them. Below, we group them into four thematic clusters.

Table 1. Overview of the contributions to the Special Issue and the role of AI, data and adaptivity.

Contribution	Type and Focus	Domain/Target Group	Role of AI, Data and Adaptivity
Papadakis et al. (Contribution 1)	Bibliometric science mapping (268 articles)	Gamification and student achievement	Identifies shift to adaptive and personalised applications
Quartulli et al. (Contribution 2)	Systematic review (59 studies)	Software engineering education	GenAI agents, intelligent tutoring, learning analytics, process mining
Gong et al. (Contribution 3)	Systematic review and bibliometric mapping (70 studies)	Team collaboration in MMOGs	Input–process–output model for collaborative and agent-supported play
Amiruzzaman et al. (Contribution 4)	Gamified accessible vocabulary game	Deaf learners	Machine-learning sign language recognition as game input
Abdullah et al. (Contribution 5)	Adaptive tablet intervention (GrowMore)	Children with intellectual disabilities	Difficulty engine; K-means clustering with clinician judgement
Tangsiripaiboon et al. (Contribution 6)	Game-based screening tool (Direction Game)	Children at risk of dyslexia	Mouse-tracking; machine-learning risk classification
Parrales-Bravo et al. (Contribution 7)	Conscientisation quiz game (CONGA)	Health literacy, university students	Adaptive difficulty grounded in critical pedagogy
Gentile et al. (Contribution 8)	Virtual reality game (XRSkills)	Teachers' stress management	Immersive scenario-based practice
Pontes et al. (Contribution 9)	Modular non-immersive VR framework	Telerehabilitation	Therapist-configurable parameters; performance data
Santórum et al. (Contribution 10)	Hybrid tangible serious game (Frutopia)	Multisensory and tactile learning	Tangible, multisensory interaction
Jiménez-Valverde et al. (Contribution 11)	Narrative web-based gamification	Initial teacher education (science)	Player-informed design
Díaz-López et al. (Contribution 12)	Mixed-methods quasi-experiment (n = 239)	Medical education	SEM, latent profile and network analyses of learner experience
Villagómez-Palacios et al. (Contribution 13)	Game development with visual scripting	Programming education	Learning by making games

MMOG: massively multiplayer online game; VR: virtual reality; SEM: structural equation modelling; GenAI: generative artificial intelligence.

3.1. Mapping the Field: Reviews and Bibliometric Analyses

Three contributions take stock of the field. Papadakis et al. (Contribution 1) present a longitudinal science-mapping analysis of 268 journal articles on gamification and student achievement, distinguishing three periods (2006–2019, 2020–2022 and 2023–2025). Gamification remains the central theme throughout, but the conceptual structure of the field shifts from motivation and engagement, through the online and digital learning environments of the pandemic period, towards adaptive, personalised and domain-specific applications. This trajectory provides an empirical confirmation of the move towards AI-enabled personalisation that motivates this Editorial.

Quartulli et al. (Contribution 2) systematically review 59 primary studies (2020–2025) on adaptive architectures for gamified learning in software engineering education. They identify three architectural patterns—immersive virtual and mixed reality environments, generative-AI-driven agents and chatbots (including multi-agent simulations of software development teams), and web-based intelligent tutoring systems—and show how

learning analytics and process mining are used to reconstruct learner trajectories, cluster students and tune difficulty dynamically. They also point to open challenges in interoperability, common assessment criteria, cognitive load and scalability, providing a valuable reference architecture for future AI-enhanced gamified systems.

Gong et al. (Contribution 3) combine a systematic review and a bibliometric mapping of 70 studies on team collaboration in massively multiplayer online games (MMOGs). Task interdependence, communication, trust, leadership and player behaviour emerge as the dominant factors, and the authors propose an input–process–output model linking game features and team processes to team performance and player experience. This model is directly relevant to the design of collaborative serious games and to future AI teammates and agents in multiplayer learning environments.

3.2. AI, Machine Learning and Adaptive Personalisation

Four contributions demonstrate how machine learning and adaptivity can make games more personal and more inclusive. Amiruzzaman et al. (Contribution 4) present a browser-based, gamified word-search game for deaf learners in which American Sign Language (ASL) signs captured by a standard webcam are recognised by a machine-learning model (88.48% Top-5 accuracy on WLASL-100) and used as game input. The work shows how AI-based recognition can transform an accessibility barrier into a core game mechanic, and it is a compelling example of AI for inclusive game-based learning.

Abdullah et al. (Contribution 5) introduce GrowMore, an adaptive tablet-based intervention for children with mild-to-moderate intellectual disabilities. The system combines a difficulty engine that adjusts task complexity to performance with a hybrid stratification approach in which clinicians' judgement is refined by K-means clustering of adaptive behaviour and sensory profiles. Over eight weeks, participants showed gains in cognitive measures and high usability ratings, illustrating a human-in-the-loop model of AI-based personalisation that keeps professionals at the centre of decisions.

Tangsiripaiboon et al. (Contribution 6) introduce the Direction Game, a set of language-independent mini-games that use mouse-tracking to capture behavioural signals related to directional perception, a common difficulty among children at risk of dyslexia. In a pilot with 102 primary school students, concentration-related variables, particularly attentional control and visuo-motor planning, proved more informative than simple accuracy scores, machine learning models showed promising classification performance relative to standardised school screening protocols, and an exploratory trajectory analysis revealed five tentative interaction profiles (hesitation, impulsivity, deliberate processing, fluent performance and disengagement). The study illustrates how fine-grained interaction data collected through play can support accessible, preliminary risk assessment in the classroom, a form of game-based stealth assessment with clear diagnostic value.

Parrales-Bravo et al. (Contribution 7) present CONGA, a conscientisation game grounded in Freirean critical pedagogy that combines adaptive difficulty with AI-generated or manually created questions and feedback, designed to improve colon cancer literacy among software engineering students. In a controlled comparison, the game group outperformed a lecture-based group in post-test performance. The study shows how adaptive mechanics can be combined with an explicit pedagogical theory—precisely the type of alignment that recent reviews identify as critical for effectiveness [14]—while the authors rightly acknowledge that their results concern short-term gains.

3.3. Immersive, Tangible and Embodied Serious Games

Three contributions explore how immersive and physical interaction can broaden the reach of serious games. Gentile et al. (Contribution 8) report a multi-country feasibility study of XRSkills, a virtual reality game that places teachers in realistic school scenarios

to practise strategies for coping with occupational stress. Usability and engagement were rated positively, while participants asked for clearer guidance, richer content and improved performance, offering concrete design lessons for immersive professional development.

Pontes et al. (Contribution 9) propose a modular, non-immersive virtual reality basketball game framework for telerehabilitation, with therapist-configurable parameters, tested with people with cerebral palsy, Down syndrome and autism spectrum disorder. Improvements in accuracy over eight sessions support the feasibility of low-cost, configurable serious games for remote therapy, and the modular architecture opens the way to data-driven adaptation.

Santórum et al. (Contribution 10) present Frutopia, a hybrid tangible serious game in which players navigate a maze by touching conductive objects with different textures, enabling multisensory interaction and tactile exploration. The high functional and usability results highlight the value of tangible interfaces for inclusive and embodied learning, a dimension often overlooked in screen-based game-based learning.

3.4. Gamification Design, Pedagogy and Learning by Making Games

The final three contributions focus on the pedagogical design of gamified and game-making experiences. Jiménez-Valverde et al. (Contribution 11) describe *Potions & Dragons*, a player-informed narrative gamification of a science didactics course in initial teacher education. Pre-service primary teachers showed improved attitudes towards science, especially towards their future science teaching, and reported reduced anxiety, showing how gamification can target affective and attitudinal outcomes that are critical for teacher education.

Díaz-López et al. (Contribution 12) address one of the central gaps identified above in a mixed-methods quasi-experimental study with 239 medical students. A browser-based game was used either alone or embedded in a blended design that added preparatory instruction and post-game debriefing. The blended group answered substantially more knowledge items correctly (88.7% vs. 65.2%), and motivation and autonomy, rather than immersion or cognitive load, were associated with perceived learning. Their "engagement–learning paradox" offers a powerful argument that games must be embedded in reflective pedagogical designs, an argument that becomes even more important when AI is used to make games more engaging.

Finally, Villagómez-Palacios et al. (Contribution 13) show that having university students develop video games with Unity Visual Scripting, a block-based environment, led to better grades, faster development of core mechanics and higher self-reported confidence than a previous text-based approach. This contribution reminds us that learning *by making* games remains a powerful strategy, one that generative AI coding assistants will profoundly transform.

3.5. How the Special Issue Addresses Current Gaps

Taken together, these contributions respond to several of the gaps outlined in Section 2. They provide new, field-level evidence on how research is evolving (Contributions 1–3); they show concrete ways of aligning adaptivity with pedagogical theory and professional judgement (Contributions 5 and 7); they expand game-based learning to underserved groups, including deaf learners, children with intellectual disabilities, children at risk of dyslexia and people undergoing rehabilitation (Contributions 4–6,9,10); and they offer an empirical account of why engagement alone is not enough (Contribution 12). At the same time, most studies remain feasibility studies, pilot evaluations or quasi-experiments with short durations, and only a few explicitly address ethics, privacy or the governance of learner data. These limitations define much of the research agenda ahead.

4. Future Research Directions

Building on the contributions to this Special Issue and on recent developments in the field, we propose the following directions for research on AI-enhanced game-based learning, gamification and serious games.

Theory-driven and human-in-the-loop adaptivity. Future systems should make explicit the pedagogical model behind each adaptation and allow learners, teachers and therapists to inspect, negotiate and override AI decisions. Hybrid approaches, such as the clinician-plus-clustering stratification of GrowMore (Contribution 5), and reference architectures, such as those reviewed by Quartulli et al. (Contribution 2), provide useful starting points.

Trustworthy learner modelling and stealth assessment. Combining game telemetry, learning analytics and machine learning offers the possibility of continuous, unobtrusive and formative assessment [9,10], as well as early, low-cost screening of learning difficulties (Contribution 6). Research is needed on validity, fairness and explainability, particularly because such systems may be considered high-risk under the AI Act [17].

Generative AI as a pedagogical partner, with guardrails. LLM-driven NPCs, game masters and conversational tutors can provide open-ended dialogue, personalised feedback and dynamic narratives [12]. However, evidence that unrestricted AI assistance can harm learning [16], while pedagogically designed AI tutors can enhance it [15], suggests that game mechanics themselves should act as guardrails, rewarding productive struggle, reflection and transfer rather than answer retrieval. Debriefing and reflective activities around games (Contribution 12) are natural places to integrate such support.

Generative and procedural content to lower development costs. Generative AI can support the whole serious game lifecycle [13], enabling teachers and domain experts to co-create, localise and update games. Studies should assess the quality, accuracy and cultural appropriateness of AI-generated content, the roles of human designers, and the sustainability of the resulting games.

AI for inclusion and accessibility. Sign language recognition (Contribution 4), game-based screening of learning difficulties (Contribution 6), multisensory and tangible interfaces (Contribution 10) and adaptive rehabilitation games (Contribution 9) show the potential of AI and novel interaction techniques to include learners who are often excluded. Future research should involve these communities in co-design and address the risk of bias in models trained on non-representative data.

AI, extended reality and collaboration. The convergence of AI with virtual, augmented and mixed reality—for instance, intelligent virtual agents in immersive training scenarios such as XRSkills (Contribution 8)—and with collaborative multiplayer environments (Contribution 3) opens a promising space for simulation-based professional training and for AI teammates in collaborative learning.

Robust and longitudinal evaluation. The field needs more randomised and longitudinal designs, delayed post-tests measuring retention and transfer, shared outcome measures and open data and code, so that findings can be compared and synthesised [4,6,14]. Reporting standards should include explicit descriptions of the role played by AI in the intervention.

Ethics, privacy, regulation and AI literacy. Research should address data protection, consent, transparency and the protection of minors and vulnerable users by design [18,19], as well as the AI and game literacy of teachers, who remain essential mediators between games and learning.

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5. Conclusions

The thirteen contributions in this Special Issue confirm the vitality and diversity of research on game-based learning, gamification and serious games, and demonstrate how AI, machine learning, immersive technologies and novel interfaces are expanding what learning games can do and whom they can reach. They also show that the key to effectiveness lies not in technology alone but in its alignment with sound pedagogical design, appropriate instructional support and the needs of specific learners. As AI becomes an integral part of learning games, the research community has both an opportunity and a responsibility to build systems that are effective, inclusive, transparent and trustworthy. We hope that this collection will serve as a reference for researchers and practitioners and will stimulate further work along the directions outlined above.

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Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial intelligence
ASL	American Sign Language
GenAI	Generative artificial intelligence
LLM	Large language model
MMOG	Massively multiplayer online game
NPC	Non-player character
VR	Virtual reality
XR	Extended reality

List of Contributions

1. Papadakis, S.; Karaköse, T.; Yirci, R.; Tülübaş, T.; Demir, I. From Gamification to Student Achievement: A Longitudinal Conceptual Structure Analysis of a Research Field. *Computers* **2026**, *15*, 242. https://doi.org/10.3390/computers15040242.
2. Quartulli, A.A.; Mignogna, G.; Zizzo, V.; Mongiello, M. Adaptive Architectures for Gamified Learning in Software Engineering: A Systematic Review. *Computers* **2026**, *15*, 235. https://doi.org/10.3390/computers15040235.
3. Gong, X.; Abdullah, L.N.; Jantan, A.H.; Norowi, N.M.; Wijaya, R.F.; Sitorus, Z.; Syahputra, Z.; Khairul. Understanding Team Collaboration in MMOGs: A Systematic Review and Bibliometric Mapping. *Computers* **2026**, *15*, 134. https://doi.org/10.3390/computers15020134.

4. Amiruzzaman, S.; Batchu, R.M.; Amiruzzaman, M.; Ngo, L.; Dewan, M.A.A. ASL Recognition and Game-Based Interaction: A Machine Learning–Driven, Gamified and Accessible Vocabulary Learning System for Deaf Learners. *Computers* **2026**, *15*, 299. https://doi.org/10.3390/computers15050299.
5. Abdullah; Hafeez, N.; Sardar, K.; Uroosa, F.; Fatima, Z.; Quintero Téllez, R.; Oropeza Rodríguez, J.L. GrowMore: Adaptive Tablet-Based Intervention for Education and Cognitive Rehabilitation in Children with Mild-to-Moderate Intellectual Disabilities. *Computers* **2025**, *14*, 495. https://doi.org/10.3390/computers14110495.
6. Tangsiripaiboon, N.; Ramingwong, S.; Cosh, K.; Eiamkanitchat, N.; Ramingwong, L. Directional Perception in Game-Based Dyslexia Risk Screening: A Mouse-Tracking Analysis. *Computers* **2025**, *14*, 532. https://doi.org/10.3390/computers14120532.
7. Parrales-Bravo, F.; Guillen-Salabarria, J.; Jadán-Guerrero, J.; Vasquez-Cevallos, L. CONGA: CONscientization GAme for Colon Cancer Literacy in Last-Semester Software Engineering Students. *Computers* **2026**, *15*, 143. https://doi.org/10.3390/computers15030143.
8. Gentile, A.; Alesi, M.; Mikaelsson, S.; Vaz de Carvalho, C. Reducing Teachers' Stress Through a Virtual Reality Game: A Feasibility Study of the XRSkills Game. *Computers* **2026**, *15*, 175. https://doi.org/10.3390/computers15030175.
9. Pontes, R.G.; Dias, E.D.; Weingartner, J.P.; Monteiro, N.K.; Valenzuela, E.J.; Rosa, R.M.; Silva, V.Y.H.; Moraes, Í.A.P.; Silva-Magalhães, T.D.; Monteiro, C.B.M.; et al. A Modular Non-Immersive VR Serious Game Framework for Telerehabilitation: Design and Proof-of-Concept Feasibility Study. *Computers* **2026**, *15*, 192. https://doi.org/10.3390/computers15030192.
10. Santórum, M.; Morales-Martínez, D.; Carrión-Toro, M.; Tapia, T.; Aguilar, J.; Santórum, K.; Acosta-Vargas, P. Frutopia: A Hybrid Tangible Serious Game for Multisensory Interaction and Tactile Exploration. *Computers* **2026**, *15*, 574. https://doi.org/10.3390/computers15090574.
11. Jiménez-Valverde, G.; Fabre-Mitjans, N.; Guimerà-Ballesta, G. Potions & Dragons: Player-Informed Web-Based Gamification for Science Attitudinal Change in Initial Teacher Education. *Computers* **2026**, *15*, 78. https://doi.org/10.3390/computers15020078.
12. Díaz-López, M.M.; Gómez Restrepo, L.A.; Ordonez, P.D.; Bustos, R.-H. The Engagement–Learning Paradox: A Mixed-Methods Study Toward Reflective Gamified Learning in Medical Education. *Computers* **2026**, *15*, 664. https://doi.org/10.3390/computers15100664.
13. Villagómez-Palacios, Á.; De la Fuente-Burdiles, C.; Vidal-Silva, C. Videogame Programming & Education: Enhancing Programming Skills Through Unity Visual Scripting. *Computers* **2026**, *15*, 68. https://doi.org/10.3390/computers15010068.

References

1. Vaz de Carvalho, C.; Coelho, A. Game-Based Learning, Gamification in Education and Serious Games. *Computers* **2022**, *11*, 36. https://doi.org/10.3390/computers11030036.
2. Deterding, S.; Dixon, D.; Khaled, R.; Nacke, L. From Game Design Elements to Gamefulness: Defining "Gamification". In Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, Tampere, Finland, 28–30 September 2011; pp. 9–15. https://doi.org/10.1145/2181037.2181040.
3. Agrawal, S.; Simon, A.; Bech, S.; Bæntsen, K.; Forchhammer, S. Defining Immersion: Literature Review and Implications for Research on Audiovisual Experiences. *J. Audio Eng. Soc.* **2020**, *68*, 404–417. https://doi.org/10.17743/jaes.2020.0039.
4. Clark, D.B.; Tanner-Smith, E.E.; Killingsworth, S.S. Digital Games, Design, and Learning: A Systematic Review and Meta-Analysis. *Rev. Educ. Res.* **2016**, *86*, 79–122. https://doi.org/10.3102/0034654315582065.
5. Mayer, R.E. Computer Games in Education. *Annu. Rev. Psychol.* **2019**, *70*, 531–549. https://doi.org/10.1146/annurev-psych-010418-102744.
6. Sailer, M.; Homner, L. The Gamification of Learning: A Meta-Analysis. *Educ. Psychol. Rev.* **2020**, *32*, 77–112. https://doi.org/10.1007/s10648-019-09498-w.
7. Yannakakis, G.N.; Togelius, J. *Artificial Intelligence and Games*; Springer: Cham, Switzerland, 2018. https://doi.org/10.1007/978-3-319-63519-4.

8. Westera, W.; Prada, R.; Mascarenhas, S.; Santos, P.A.; Dias, J.; Guimarães, M.; Georgiadis, K.; Nyamsuren, E.; Bahreini, K.; Yumak, Z.; et al. Artificial Intelligence Moving Serious Gaming: Presenting Reusable Game AI Components. *Educ. Inf. Technol.* **2020**, *25*, 351–380. https://doi.org/10.1007/s10639-019-09968-2.
9. Hooshyar, D.; Yousefi, M.; Lim, H. Data-Driven Approaches to Game Player Modeling: A Systematic Literature Review. *ACM Comput. Surv.* **2018**, *50*, 90. https://doi.org/10.1145/3145814.
10. Shute, V.J. Stealth Assessment in Computer-Based Games to Support Learning. In *Computer Games and Instruction*; Tobias, S., Fletcher, J.D., Eds.; Information Age Publishing: Charlotte, NC, USA, 2011; pp. 503–524.
11. Zawacki-Richter, O.; Marín, V.I.; Bond, M.; Gouverneur, F. Systematic Review of Research on Artificial Intelligence Applications in Higher Education—Where Are the Educators? *Int. J. Educ. Technol. High. Educ.* **2019**, *16*, 39. https://doi.org/10.1186/s41239-019-0171-0.
12. Gallotta, R.; Todd, G.; Zammit, M.; Earle, S.; Liapis, A.; Togelius, J.; Yannakakis, G.N. Large Language Models and Games: A Survey and Roadmap. *IEEE Trans. Games* **2024**. https://doi.org/10.1109/TG.2024.3461510.
13. Swacha, J.; Gracel, M. Supporting Serious Game Development with Generative Artificial Intelligence: Mapping Solutions to Lifecycle Stages. *Appl. Sci.* **2025**, *15*, 11606. https://doi.org/10.3390/app152111606.
14. Kaşarcı, İ.; Yurt, E. Effectiveness of AI-Supported Game-Based Learning: A Systematic Review of Outcomes, Challenges, and Future Directions. *Behav. Sci.* **2026**, *16*, 1050. https://doi.org/10.3390/bs16071050.
15. Kestin, G.; Miller, K.; Klales, A.; Milbourne, T.; Ponti, G. AI Tutoring Outperforms In-Class Active Learning: An RCT Introducing a Novel Research-Based Design in an Authentic Educational Setting. *Sci. Rep.* **2025**, *15*, 17458. https://doi.org/10.1038/s41598-025-97652-6.
16. Bastani, H.; Bastani, O.; Sungu, A.; Ge, H.; Kabakcı, Ö.; Mariman, R. Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics. *Proc. Natl. Acad. Sci. USA* **2025**, *122*, e2422633122. https://doi.org/10.1073/pnas.2422633122.
17. European Parliament and Council of the European Union. Regulation (EU) 2024/1689 of 13 June 2024 Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act). *Off. J. Eur. Union* **2024**, L 2024/1689. Available online: https://eur-lex.europa.eu/eli/reg/2024/1689/oj (accessed on 7 November 2026).
18. Miao, F.; Holmes, W. *Guidance for Generative AI in Education and Research*; UNESCO: Paris, France, 2023. https://doi.org/10.54675/EWZM9535.
19. Holmes, W.; Porayska-Pomsta, K.; Holstein, K.; Sutherland, E.; Baker, T.; Buckingham Shum, S.; Santos, O.C.; Rodrigo, M.T.; Cukurova, M.; Bittencourt, I.I.; et al. Ethics of AI in Education: Towards a Community-Wide Framework. *Int. J. Artif. Intell. Educ.* **2022**, *32*, 504–526. https://doi.org/10.1007/s40593-021-00239-1.

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