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AI-BASED GAMIFICATION FOR INTERACTIVE LEARNING: CHANGING METHODOLOGIES IN TEACHING

Annotation. *Gamification in education has emerged as a powerful tool to enhance student engagement and learning outcomes. By integrating Artificial Intelligence (AI) into gamified learning environments, educational institutions are revolutionizing the way students interact with content. AI-based gamification not only makes learning fun but also adapts to individual learning needs, ensuring personalized educational experiences. This paper explores the integration of AI with gamification in teaching, examining how AI can be utilized to enhance motivation, engagement, and overall learning efficiency. Key aspects include game mechanics, AI tools for personalized learning, and theoretical frameworks supporting gamified educational systems.*

Key words: *AI-based gamification, interactive learning, personalized education, student engagement.*

Анотація. *Гейміфікація в освіті стала потужним інструментом для підвищення залученості студентів та результатів навчання. Інтегруючи штучний інтелект (ШІ) у гейміфіковані навчальні середовища, навчальні заклади революціонізують спосіб взаємодії студентів з контентом. Гейміфікація на основі ШІ не лише робить навчання цікавим, але й адаптується до індивідуальних потреб у навчанні, забезпечуючи персоналізований освітній досвід. У цій статті досліджується інтеграція ШІ з гейміфікацією у викладання, розглядаючи, як ШІ*

можна використовувати для підвищення мотивації, залученості та загальної ефективності навчання. Ключові аспекти включають ігрову механіку, інструменти ШІ для персоналізованого навчання та теоретичні основи, що підтримують гейміфіковані освітні системи.

Ключові слова: *гейміфікація на основі ШІ, інтерактивне навчання, персоналізована освіта, залученість студентів.*

Introduction. The increasing role of technology in education has spurred a transformation in how teaching and learning are approached. Traditional methods are being augmented by interactive digital tools, one of the most prominent being gamification. By incorporating elements of game design-such as challenges, rewards, and feedback-into non-game contexts, gamification has been shown to improve student motivation and learning outcomes. With the rise of Artificial Intelligence (AI), gamification in education has taken on a more personalized and adaptive form. This article delves into how AI-based gamification is reshaping modern teaching methodologies and improving interactive learning experiences for students across all levels of education [3].

The article Aim. This article aims to explore the integration of AI with gamification in the classroom, highlighting its role in enhancing student engagement, motivation, and personalized learning. It will also examine the theoretical foundations supporting this approach and the practical implications for educators.

Research Results. Need for Gamification in Teaching.

The following are the need for the gamification in Teaching [7]:

- **Increased Engagement**: Traditional education often struggles to keep students motivated. Gamification introduces an element of fun that can captivate students' attention.

- **Immediate Feedback**: Gamification allows for real-time feedback, helping students track their progress and make adjustments during the learning process.

- **Enhanced Motivation**: Points, badges, leader boards, and rewards boost motivation by offering tangible incentives for learning accomplishments.

- **Personalized Learning**: Through AI integration, gamified systems can adapt to individual learning styles, allowing for tailored educational experiences.

- **Collaborative Learning**: Gamification encourages teamwork and peer interaction, promoting social learning through group challenges and collaborative tasks.

- **Skill Development**: Games are designed to challenge learners at their level, enhancing skills and building competency through progressive challenges.

- **Encourages Risk-Taking**: The low-risk environment of a gamified system allows students to experiment and make mistakes without fear of judgment, enhancing their learning potential.

- **Time Management**: Gamification motivates students to manage their time effectively through structured challenges and deadlines.

- **Data-Driven Insights**: AI tools embedded in gamified systems provide detailed analytics on student performance, helping educators make informed decisions.

- **Improved Retention**: The immersive and interactive nature of gamified learning increases retention by making concepts more memorable and engaging.

Theoretical Foundations of Gamification for Teaching and Learning

Several educational theories underpin the use of gamification in learning [1]:

- **Self-Determination Theory (SDT)**: Emphasizes autonomy, competence, and relatedness as key factors in motivating students. Gamification supports these elements by allowing students to make choices, feel competent through achievement, and engage with peers in collaborative tasks.

- **Gamification Theory**: This theory posits that integrating game-like elements, such as points, badges, and leaderboards, can enhance student motivation and learning engagement.

- **Adaptive Learning Theory**: AI allows for real-time adjustments to learning material based on individual student needs, optimizing educational experiences.

- **Constructivist Learning Theory**: Encourages active learning and critical thinking. Gamification promotes these elements through problem-solving activities and interactive challenges.

- **Flow Theory**: Describes the state of deep engagement when students are immersed in an appropriately challenging task. Gamification can maintain students in this state by offering progressive challenges.

- **Vygotsky's Sociocultural Theory**: Highlights the importance of social interaction in learning. Gamification fosters collaboration and peer-based learning.

- **Behaviorist Learning Theory**: Focuses on reinforcement and rewards. Gamification incorporates rewards and progress tracking to reinforce desired behaviors.

- **Cognitive Load Theory**: Emphasizes the importance of not overwhelming students with excessive information. Gamified learning can help manage cognitive load by breaking tasks into manageable units.

- **Experiential Learning Theory**: Advocates learning through direct experience. Gamification provides an experiential learning environment where students can actively engage with content.

- **Social Learning Theory**: Suggests that learning is influenced by observing others. In gamified settings, peer interaction and social sharing can enhance learning outcomes.

Usage of AI Tools for Gamified Learning.

AI tools have revolutionized gamified learning by providing personalized experiences, adapting content based on student performance, and offering real-time analytics. Tools such as **Kahoot**, **SoloLearn**, and **Quizizz** employ AI to create dynamic quizzes and learning modules that adjust to each student's pace and ability level. AI also facilitates the use of **intelligent tutoring systems** and **chatbots** that provide instant feedback, helping students learn from their mistakes. Moreover, AI-powered platforms can predict future learning challenges and suggest content to address gaps in knowledge, enhancing both engagement and learning outcomes [8].

Integrating Artificial Intelligence (AI) for personalized and adaptive learning is shown in Figure 1.
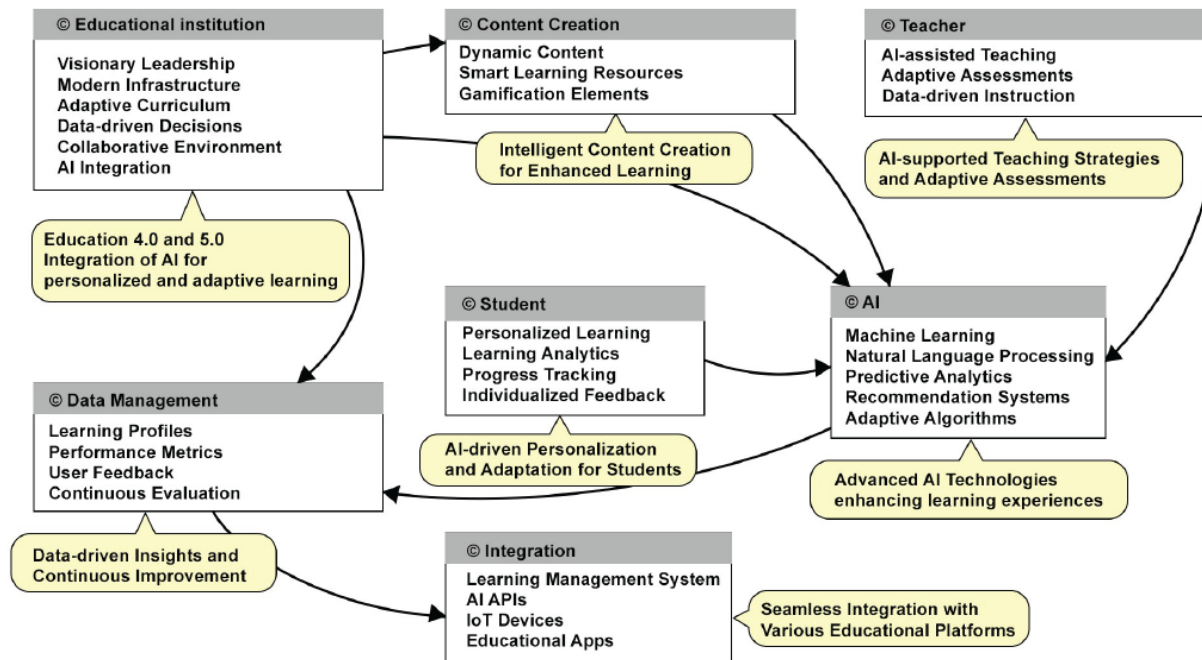
Fig. 1. Integrating Artificial Intelligence (AI) for personalized and adaptive learning *

** **Source:** Education 4.0 and 5.0: integrating Artificial Intelligence (AI) for personalized and adaptive learning (https://www.reseaprojournals.com/jair/192)*

Elements in Designing a Gamified Module Using AI [6; 7]:

- **Intrinsic Motivation**: Encouraging autonomy, competence, relatedness, purpose, and curiosity through personalized learning experiences.

- **Extrinsic Motivation**: Utilizing badges, trophies, leaderboards, rewards, points, and unlockables to drive students' motivation.

- **Game Mechanics**: Defining clear objectives, actions, rules, feedback systems, and progression to maintain student engagement.

- **Immersive Dynamics**: Integrating storytelling, aesthetics, emotional engagement, and interactive environments, including Virtual Reality (VR) for enhanced learning.

- **Personalization**: Tailoring learning paths based on user preferences, behavioral analysis, and adaptive difficulty adjustments.

- **AI Learning Capabilities**: Leveraging supervised learning, reinforcement learning, neural networks, natural language processing, and computer vision for real-time feedback and content generation.

- **User Interface & Experience**: Ensuring intuitive design, easy navigation, clear visual elements, and effective feedback mechanisms.

- **Social Interaction**: Promoting multiplayer features, collaboration, competition, and community building for enhanced learning.

- **Ethical Considerations**: Addressing data privacy, bias mitigation, transparency, fairness, and accountability in AI tools.

- **Performance and Efficiency**: Focusing on scalability, robust performance, and efficient error handling to ensure a smooth learning experience.

Levels of Education Through Gamification Using AI. AI-based gamification operates across three levels of education to enhance learning experiences. At the **micro level**, it focuses on individual learning by offering personalized paths and adaptive feedback, tailoring content to each student's needs. The **meso level** emphasizes group collaboration, where AI supports real-time teamwork and interactive challenges, fostering peer engagement and cooperative learning. At the **macro level**, AI-driven gamification can influence large-scale educational systems by promoting cultural shifts and providing global access to diverse learning styles, thus reshaping the educational landscape on a broader scale [5].

Benefits of Using Machine Learning in Gamification in Teaching.

AI-based gamification in education offers several benefits, starting with the ability to analyze large volumes of student data to gain data-driven insights, perform behavior analysis, identify trends, and predict performance. It also helps build teaching tools, such as personalized content, AI tutors, learning resource recommendations, and content generation. AI enables the monitoring and mentoring of learning progress through real-

time tracking, automated feedback, and progress monitoring. Additionally, it can adjust to learners' needs by dynamically adapting content, personalizing learning paths, and adjusting difficulty in real-time. With predictive analytics, AI can forecast learning outcomes, identify risks, and enable early intervention. AI also enhances engagement and motivation by analyzing engagement metrics, personalizing reward systems, and boosting motivation. AI also helps facilitate collaborative learning through group challenges, peer matching, and social learning optimization. Finally, it automates administrative tasks such as grading, content management, and reporting, significantly reducing the workload for educators [8].

Procedure for Designing a Gamified Learning Module Integrating AI [8]:

- **Define Learning Objectives**: Establish clear educational goals aligned with intended outcomes.

- **Gamification Strategy**: Decide on levels, rewards, and challenges to motivate students.

- **Text Generation Modules Using OpenAI**: Personalize problems or explanations based on student queries.

- **AI-Powered Tutors**: Use AI to provide assistance and clarification in subjects like history or math.

- **Embeddings for Contextual Understanding**: Recommend lessons based on students' performance and needs.

- **Tokenization for Managing Text**: Assist in grammar correction or pronunciation for language learning.

- **API Keys for Integration**: Integrate external AI services like OpenAI's GPT for automatic content generation.

- **Function Calling for AI Actions**: Generate new challenges when students level up.

- **Model Fine-Tuning**: Adjust difficulty in real-time based on learner progress.

- **Personalized Learning Path**: Recommend challenges according to proficiency.

- **Data Analytics for Tracking**: Analyze student data to adjust difficulty levels.

- **Feedback Mechanism**: Collect student feedback to improve the system.

- **Testing and Deployment**: Continuously monitor and improve AI tools based on user feedback.

The Scores/Rubrics in Gamified Learning are shown in Table 1.

Table 1

Scores/Rubrics in Gamified Learning

Type of Score - Description	Example
ELO Scores- Ranks learners based on performance and adjusts challenges accordingly.	In a math quiz, a student's ELO score changes based on their accuracy and the difficulty of the questions.
MMLU Scores- Measures mastery across multiple tasks for diverse subjects.	A student's MMLU score reflects their ability to solve reading comprehension, problem-solving, and grammar tasks across different subjects.
XP (Experience Points)- Rewards students for task completion, encouraging continued engagement.	A student earns XP after completing chapters in a science module, unlocking more advanced topics as they progress.
Leaderboards- Ranks students, fostering competition and motivation to improve performance.	A leaderboard displays the top-performing students in a coding challenge, motivating others to improve.
Badges- Visual rewards for completing tasks or mastering skills.	A "Problem Solver" badge is awarded to a student after successfully solving a series of challenging puzzles.
Level Progression-Tracks progress and indicates readiness for more advanced material.	A student moves from beginner to advanced levels in a language learning app as they pass quizzes.
Skill Points- Rewards proficiency in specific skills, allowing detailed evaluation.	In a history module, students earn skill points for mastering topics such as Ancient Rome or the Industrial Revolution.
Completion Rate- Reflects how many tasks have been completed, showcasing learner engagement.	A student's completion rate increases as they finish interactive lessons and quizzes in a course.
Time-Based Challenges- Evaluates the speed and efficiency of completing tasks, promoting quick thinking.	A student must complete a set of math problems within a time limit, with points awarded for accuracy and speed.
Achievement Points (AP)- Awards points for reaching milestones within the learning process.	A student earns Achievement Points for completing a set of difficult art assignments, signaling mastery.
Reputation Score- Measures contributions to the learning community, fostering collaboration.	A student earns reputation points by helping classmates with difficult concepts during group discussions.
Peer Reviews/Ratings- Allows students to evaluate and give feedback on each other's work.	During a group project, students rate each other's research presentations for creativity and quality.

Conclusions. AI-based gamification is transforming the educational landscape by creating interactive, personalized, and engaging learning environments. The integration of AI not only enhances student motivation and learning outcomes but also enables tailored learning experiences. As educational methodologies evolve, the collaboration between AI and gamification offers a promising future for interactive learning. By ensuring ethical considerations and focusing on performance, the next generation of education systems can offer scalable, effective, and engaging learning solutions for all students.

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