METHODOLOGY FOR DEVELOPING METACOGNITIVE COMPETENCIES THROUGH GAMIFICATION AND DIDACTIC GAMES IN THE EDUCATIONAL PROCESS - ARTIFICIAL INTELLIGENCE AND INCLUSIVE EDUCATION

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Abstract: This article theoretically examines the issue of developing metacognitive competencies in students through gamification and didactic games, with an expanded focus on the integration of artificial intelligence (AI) technologies and inclusive education. The main theories are analyzed from the perspective of pressing problems in Uzbekistan's education system and the reforms outlined in the "New Uzbekistan" development strategy (PD-60, 2022). The scientific foundations of metacognition are examined through the theories of John Flavell (1976), Ann Brown (1987), and Barry Zimmerman (2000). The four main components of metacognitive competencies — planning, monitoring, evaluation, and reflection — are analyzed in the context of didactic games and AI-enhanced learning environments. A dedicated section addresses how AI-powered adaptive gamification serves as a tool for inclusive education, enabling personalized learning pathways for students with diverse needs. The pedagogical effectiveness of gamification is substantiated through Self-Determination Theory (Deci Ryan, 1985) and Flow Theory (Csikszentmihalyi, 1990). Psychological safety, ethical dimensions of AI use, and teacher digital competence are also examined as critical preconditions for effective inclusive AI integration. The article concludes that the synergy of gamification, didactic games, and AI technologies constitutes a comprehensive and ethically grounded approach to developing metacognitive competencies in inclusive educational settings.

Keywords: metacognition, metacognitive competence, gamification, didactic game, artificial intelligence, inclusive education, self-regulation, personalized learning, New Uzbekistan strategy.

Annotatsiya: Ushbu maqolada gamifikatsiya va didaktik o'yinlar orqali o'quvchilarda metakognitiv kompetensiyalarni shakllantirish masalasi sun'iy intellekt (SI) texnologiyalari va inklyuziv ta'lim jihatlarini qamrab olgan holda nazariy jihatdan ko'rib chiqiladi. Asosiy nazariyalar O'zbekiston ta'lim tizimidagi dolzarb muammolar va "Yangi O'zbekiston" taraqqiyot strategiyasi (PF-60, 2022) doirasida tahlil qilinadi. Metakognitiv kompetensiyalarning to'rtta asosiy komponenti — rejalashtirish, monitoring, baholash va refleksiya — didaktik o'yinlar va SI-ga asoslangan o'quv muhitlarida qanday namoyon bo'lishi ko'rib chiqiladi. Maqolada SI-yordamida moslashtirilgan gamifikatsiyaning turli ehtiyojlarga ega o'quvchilar uchun inklyuziv ta'limni ta'minlovchi vosita sifatidagi roli alohida tahlil qilinadi. Gamifikatsiyaning pedagogik samaradorligi o'z-o'zini aniqlash nazariyasi (Deci Ryan, 1985) va oqim nazariyasi

(Chiksentmihayi, 1990) asosida asoslanadi. Psixologik xavfsizlik, SI foydalanishning axloqiy jihatlari va o‘qituvchilarning raqamli kompetentsiyasi inklyuziv SI integratsiyasi uchun muhim shart-sharoitlar sifatida ko‘rib chiqiladi.

Kalit so‘zlar: metakognitsiya, metakognitiv kompetensiya, gamifikatsiya, didaktik o‘yin, sun’iy intellekt, inklyuziv ta’lim, o‘z-o‘zini tartibga solish, shaxsiylashtirish, Yangi O‘zbekiston strategiyasi.

INTRODUCTION

In today’s educational landscape, the primary task facing educators is no longer merely the transmission of knowledge, but rather the development of students’ capacity to learn how to learn — that is, the cultivation of metacognitive competencies. The PISA-2022 results demonstrated that students with higher metacognitive indicators exhibit significantly greater levels of academic achievement . [1]Uzbekistan participated in the PISA international assessment program for the first time in 2022, and the "New Uzbekistan" development strategy (PD-60, 2022) has defined the formation of independent thinking, critical analysis, and self-development competencies as a priority direction in education .[2]

Nevertheless, pedagogical literature consistently notes that traditional teaching methods are insufficiently effective in developing metacognitive skills (Veenman, Van Hout-Wolters Afflerbach, 2006). In this regard, approaches based on gamification and didactic games are increasingly being explored as viable alternatives. A further challenge confronting contemporary education is the imperative of inclusivity: ensuring that diverse learners — including those with learning differences, language barriers, and socioeconomic disadvantages — are afforded equitable access to metacognitive skill development. The emergence of artificial intelligence (AI) technologies presents an unprecedented opportunity to address both of these challenges simultaneously, enabling the adaptive personalization of game-based learning experiences at scale.

The concept of “metacognition” was introduced into scientific discourse by American psychologist John Flavell (1976), who defined it as “knowledge about one’s own cognitive processes and the ability to monitor them”. Ann Brown (1987) subsequently distinguished two interrelated components of metacognition: metacognitive knowledge (awareness of one’s strengths and weaknesses) and metacognitive regulation (planning, monitoring, evaluation).

Barry Zimmerman (2000) depicted these two components as a cyclical process within his self-regulated learning model: forethought performance self-reflection. This model illustrates the dynamic nature of metacognitive competencies.[3]

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[1] OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

[2] Decree of the President of the Republic of Uzbekistan No. PD-60. (2022, January 23). *On the Development Strategy of New Uzbekistan for 2022–2026*. Tashkent.

[3] Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press.

Among Uzbek researchers, Urinboev M.I. (2024) studied the problem of improving metacognitive activities in secondary school students and demonstrated that the targeted formation of metacognitive skills directly contributes to improving the effectiveness of the learning process. Pardayeva M.D., Davletov N.K., Jumaev N.R. investigated the integration of metacognitive strategies into educational activities and the formation of student skills, while Nuriddinov R. and Kadirova D. conducted research on improving students' educational effectiveness through the development of metacognitive skills in the education system.

METHODOLOGY

Gamification is the technology of applying game elements (points, achievements, ratings, narratives) in non-game environments (Deterding et al., 2011). Its pedagogical effectiveness rests on several theoretical foundations.

Self-Determination Theory.

Deci and Ryan (1985) established that human beings have three fundamental psychological needs: autonomy, competence, and relatedness. Gamification satisfies all three needs, thereby enhancing intrinsic motivation. Well-designed game elements influence learners through providing choice (autonomy), enabling them to experience their capabilities through achievements (competence), and fostering connection through collaborative tasks (relatedness).

Flow Theory.

Csikszentmihalyi (1990) defined the "flow" state as a state of maximum immersion that arises when the difficulty of a task is balanced with the learner's capabilities. Gamification enables learners to be maintained in this state through the principle of progressive difficulty.[4]

DISCUSSION

A didactic game is a form of pedagogical activity that pursues educational objectives, is rule-based, and has a playful structure. Its influence on metacognition is grounded in Vygotsky's concept of the Zone of Proximal Development (ZPD): in a game environment, students are able to perform tasks that exceed their current capabilities, and through this process, they learn to consciously manage their own learning.

Three Core Mechanisms of Metacognitive Influence

Research in pedagogy has identified three primary mechanisms through which didactic games influence metacognitive skills (Veenman et al., 2006):

1. Immediate Feedback.[5]

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4 Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. Harper Row.

[5] Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning*, *1*(1), 3–14.

One of the most significant advantages of game-based learning environments is the immediacy and specificity of feedback provided to the learner. Unlike traditional classroom assessments, where feedback may be delayed by days or even weeks, didactic games offer real-time responses to student decisions and actions. This immediacy serves as a catalyst for self-assessment skills, allowing students to immediately compare their performance against intended outcomes and to recalibrate their strategies without delay. Research indicates that when students receive instant, targeted feedback, they are more likely to engage in reflective thinking and to internalize evaluative criteria, both of which are core components of metacognitive regulation (Hattie Timperley, 2007). Over time, students develop the habit of monitoring their own reasoning processes, a skill that transfers beyond the game environment into everyday academic tasks.

2. Safe Trial Environment.

A particularly important feature of well-designed didactic games is the creation of a psychologically safe space in which students can experiment freely, without the fear of failure or social judgment. In traditional educational settings, students often avoid risk-taking strategies due to anxiety about grades or peer disapproval. The game environment reframes mistakes not as failures, but as natural and informative steps in the learning process. This shift in orientation is critical for the development of reflective metacognitive practices: when students are unafraid to try different approaches, they naturally engage in strategy testing, error analysis, and iterative improvement. Zimmerman (2000) demonstrated that self-regulated learners distinguish themselves precisely through their capacity to treat setbacks as sources of useful information rather than threats to their self-concept.

3. Cognitive Load Optimization.

The progressive structuring of difficulty levels in didactic games — commonly referred to as scaffolding — plays a vital role in protecting students from cognitive overload (Sweller, 1988). When task complexity increases incrementally and in alignment with the learner's growing competence, cognitive resources are efficiently allocated. Rather than being overwhelmed by the demands of a new task, students are able to devote mental attention to higher-order processes such as planning, monitoring, and reflection.

Gamification and Metacognitive Component Development

Gamification addresses each of the four core metacognitive components in distinct and complementary ways. In terms of planning, game environments routinely require students to formulate strategies before undertaking a task: players must anticipate challenges, assess available resources, and chart a path forward. These pre-game deliberations are structurally identical to the metacognitive planning processes that characterize effective learners. With respect to monitoring, the real-time nature of games means that students are continuously engaged in assessing their progress against ongoing goals, adjusting their approach as new information emerges.

The evaluation component is reinforced through the scoring and ranking systems inherent to most games: students naturally compare their end-of-game outcomes with the strategies they employed, fostering analytical self-evaluation. Finally, reflection is explicitly promoted through post-game debriefing sessions, during which students review their decisions, discuss alternative approaches, and extract generalizable lessons.

The Convergence of AI, Gamification, and Inclusive Education

Inclusive education, as defined by UNESCO (2017), is an approach that responds to the diversity of all learners by increasing participation and reducing exclusion within and from education. Traditional classroom gamification, while beneficial, frequently encounters a critical limitation: game-based activities designed for a general student population may fail to adequately address the heterogeneous needs of learners with disabilities, language barriers, giftedness, or psycho-social difficulties. The integration of artificial intelligence into gamified learning environments offers a transformative solution to this challenge, enabling the real-time adaptive personalization of educational content, difficulty levels, and feedback modalities in ways that were previously impossible.

AI-powered gamification platforms utilize machine learning algorithms to continuously analyze learner behavior data — including response patterns, error frequency, time-on-task, and emotional indicators — and dynamically adjust the game environment to optimize engagement and cognitive challenge for each individual student. This adaptive capacity transforms the static scaffolding of traditional didactic games into a responsive, individualized support structure that operationalizes Vygotsky's ZPD for every learner simultaneously, regardless of their starting point.

Psychological Safety and Ethical Dimensions of AI in Inclusive Game-Based Learning

The introduction of AI into educational gamification raises significant questions of psychological safety and ethics that must be addressed systematically. For students with learning differences — including those with attention deficit hyperactivity disorder (ADHD), dyslexia, autism spectrum conditions, or anxiety disorders — the psychological dimensions of AI-mediated game environments are particularly consequential. Rose and Meyer's (2002) Universal Design for Learning (UDL) framework establishes that inclusive learning environments must offer multiple means of representation, action and expression, and engagement. AI systems embedded within gamified platforms can operationalize UDL principles dynamically: text can be converted to audio for learners with dyslexia; visual feedback can be supplemented with haptic responses for students with hearing impairments; and game pacing can be automatically decelerated for learners with processing difficulties.

However, the ethical deployment of AI in inclusive educational settings demands rigorous attention to several concerns. First, the collection and analysis of detailed behavioral and emotional data from students — particularly minors with disabilities — raises pressing issues of data privacy and informed consent that must be governed by clear institutional and legislative frameworks. In the context of Uzbekistan's developing digital education infrastructure, the adoption of AI gamification tools must be accompanied by the establishment of appropriate data protection regulations aligned with international standards. Second, algorithmic bias presents a

substantial risk: if AI systems are trained predominantly on data from non-representative student populations, their adaptive recommendations may systematically disadvantage the very learner groups that inclusive education is designed to support. The development and procurement of AI tools for Uzbek classrooms must therefore prioritize the use of locally representative training data and regular algorithmic audits.

Third, the psychological safety of the AI-mediated learning environment is not guaranteed simply by the removal of human judgment; students may experience anxiety, surveillance discomfort, or diminished agency if they perceive the AI system as opaque, unpredictable, or controlling. Research in educational technology has shown that students' metacognitive engagement is higher when they understand the logic of the adaptive system and feel a sense of co-authorship over their learning trajectory (Luckin, 2018). This finding underscores the importance of designing AI gamification interfaces that are transparent, explainable, and structured to reinforce, rather than supplant, learner autonomy — a design principle that is entirely consistent with Self-Determination Theory's emphasis on autonomy as a foundational psychological need.

Teacher Digital Competence as a Precondition for Inclusive AI Integration

The realization of AI-enhanced inclusive gamification in practice is inseparable from the development of teachers' digital competence and psychological readiness. Research consistently demonstrates that the effectiveness of educational technology is mediated above all by the pedagogical quality of its implementation (Fullan Langworthy, 2014). Teachers who are equipped with both the technical skills to configure and monitor AI gamification platforms and the pedagogical knowledge to interpret AI-generated learner analytics are significantly better positioned to leverage these tools for inclusive metacognitive development.

In the Uzbek context, this implies a systematic investment in teacher professional development programs that address not only the operational dimensions of AI tool use, but also the psychological dimensions of adapting to AI-mediated classrooms. Teachers must be supported in moving from a deficit-oriented perspective on diverse learners — viewing learning differences as problems to be managed — toward an assets-based inclusive orientation that regards diversity as a resource for richer collective metacognitive development. AI gamification, when implemented by teachers with this orientation, becomes an instrument not merely of differentiation, but of genuine inclusion: a means by which all students, regardless of their individual profiles, are invited into the shared metacognitive community of the classroom.

Implications for Metacognitive Development in Inclusive AI Gamification

The integration of AI into gamified didactic activities has specific and measurable implications for each of the four metacognitive components identified in this article. In the domain of planning, AI systems can provide students with explicit pre-task scaffolds that are calibrated to their individual competence profiles, modeling the metacognitive planning process and prompting students to articulate their strategies before beginning a game task. For monitoring, AI-generated real-time dashboards allow students to observe their own progress data — error rates, time allocation, strategy changes — in a format that makes the monitoring process explicit and visible, thereby externalizing a cognitive process that is typically invisible For

evaluation, AI systems can generate individualized post-game reports that compare student performance against their own prior data rather than against a normative group standard, thereby making evaluation intrinsically motivating rather than threatening. Finally, for reflection, AI-powered conversational agents — such as AI tutors embedded within gamified platforms — can guide structured debriefing conversations, posing personalized questions that prompt students to articulate the reasoning behind their in-game decisions and to identify transferable metacognitive strategies.

Implications for Uzbekistan's Educational Reform

The findings discussed above carry significant implications for the ongoing reform of Uzbekistan's educational system. Uzbekistan's PISA-2022 debut revealed performance gaps that the "New Uzbekistan" strategy (PD-60, 2022) has committed to addressing through a shift toward competency-based education. Research by Urinboev M.I. (2024, 2025) within the national context confirms that explicitly targeting metacognitive skill development produces measurable improvements in academic performance, particularly in subjects such as physics that require complex reasoning and self-monitoring.[6]

The integration of gamification, didactic games, and AI-powered inclusive tools into Uzbek classrooms therefore represents not merely a methodological novelty, but a theoretically grounded and contextually relevant response to the demands of national educational reform. For such integration to be effective, it must be accompanied by systematic teacher training in the design and facilitation of game-based metacognitive activities, the development of culturally appropriate game materials aligned with the national curriculum, and the establishment of regulatory frameworks for the ethical use of AI in educational settings. Future empirical research should prioritize controlled studies measuring the impact of AI-enhanced gamification on metacognitive components across students with diverse needs within the Uzbek educational context.

CONCLUSION

The theoretical analysis conducted in this study leads to the following conclusions:

First, metacognitive competencies — comprising planning, monitoring, evaluation, and reflection — represent one of the central objectives of contemporary education, and their development requires the deliberate creation of a specialized pedagogical environment.

Second, gamification, grounded in Self-Determination Theory and Flow Theory, constitutes an effective instrument for enhancing motivation and activating metacognitive processes across diverse learner populations.

[6] Urinboev, M. I. (2025). *Improving students' metacognitive activities in teaching physics in general secondary education schools* [Abstract of PhD dissertation, Namangan Machine-Building Institute]. NamMTI.

Third, didactic games, within the framework of Vygotsky's ZPD concept, ensure metacognitive development through immediate feedback, a safe trial environment, and cognitive load optimization.

Fourth, the integration of artificial intelligence into gamified learning environments creates an unprecedented opportunity to realize the principles of inclusive education by enabling real-time adaptive personalization, operationalizing Universal Design for Learning, and making the four metacognitive components explicit and developable for every learner, regardless of their individual profile.

Fifth, the ethical and psychologically safe implementation of AI gamification for inclusive education requires transparent algorithmic design, robust data protection frameworks, and the development of teachers' digital and inclusive pedagogical competence — all of which represent urgent priorities for Uzbekistan's ongoing educational reform agenda.

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