FROM GAME TO ALGORITHM INTEGRATION OF GAMING AND AI TO ENCOURAGE CRITICAL THINKING IN STUDENTS

Maja Mitevska-Poceva

ABSTRACT

This paper explores the role of gamification as an innovative pedagogical strategy and its integration with AI tools to promote critical thinking among primary school students. Through the analysis of contemporary theoretical models and best practices, the potential of gamified activities supported by intelligent systems to enhance students' motivation, engagement, and cognitive abilities is discussed, while simultaneously developing their critical awareness of media and digital reality. Critical thinking, as an essential competency of the 21st century, enables students to logically analyze, evaluate, and make evidence-based decisions. It represents a process that overcomes the limitations of bias, impulsive reasoning, and one-sided perspectives, relying on values such as clarity, accuracy, consistency, relevance, and fairness. In this context, artificial intelligence is not just a technological tool, but also a cognitive challenge that requires the development of critical skills for analyzing, interpreting, and evaluating algorithmically generated content. Learning with and through AI promotes awareness of how algorithms select and present information, enabling students to recognize potential manipulations, biases, and limitations of digital systems. The paper proposes an integrative learning model that connects elements of play, technology, and cognitive autonomy, creating an environment that fosters development, innovation, and freedom of thought. In this way, the integration of gamification and AI emerges as a key tool for building a generation of students who can navigate the complex informational landscape of modern society critically, creatively, and ethically.

Keywords: gamification, artificial intelligence, critical thinking, media literacy.

1. Introduction

Modern society is in a period of accelerated digital transformation, in which digital technologies and artificial intelligence (AI) have an increasingly profound impact on everyday life. The way information is created, processed, and distributed is increasingly mediated by algorithms and automated systems that participate in content selection, public opinion shaping, and decision making. In such a context, education faces an increased responsibility – to respond to the needs of generations of students who grow up in a digital and media-saturated environment, in which technology is not just a means, but an active factor in the learning and socialization process.

Students today are exposed to a continuous flow of information, which is often fragmented, algorithmically selected, and not always reliable. Traditional teaching approaches, focused mainly on the transmission and reproduction of knowledge, are increasingly proving to be insufficient for developing the skills needed for a critical understanding of the complex digital reality. Hence, the development of critical thinking is imposed as one of the key goals of modern education.

Critical thinking is considered an essential competency of the 21st century, as it enables students to approach information analytically, assess its reliability and relevance, and make reasoned decisions based on evidence. It is a complex process that includes logical reasoning, evaluation of arguments, self-reflection and awareness of one‘s own cognitive limitations. In conditions of information overload, misinformation and digital manipulations, critical thinking becomes a prerequisite for the development of responsible, autonomous and ethically aware persons.

In this educational landscape, artificial intelligence takes on a dual role. On the one hand, it is a powerful pedagogical tool that enables personalized and adaptive learning, automatic feedback, and monitoring of student progress. On the other hand, AI presents a cognitive and ethical challenge because the algorithms that support its functionality often function as non-transparent systems, whose influence on opinion and behavior is not always easily recognizable. Therefore, learning with and about artificial intelligence should not be reduced to technical literacy, but should include developing a critical awareness of the way algorithms mediate information and shape digital reality.

In parallel with technological advancements, contemporary pedagogy is increasingly emphasizing the importance of active and student-centered teaching approaches. In that direction, gamification stands out as an effective pedagogical strategy that integrates game elements into the teaching process to increase student motivation, engagement, and cognitive activity. The game, as a natural form of learning, creates a safe environment for research, experimentation, and learning through experience, which is particularly significant for the development of logical, creative, and critical thinking.

Gamified activities allow students to actively participate in solving problems, making decisions and developing strategies, whereby learning is experienced as a meaningful and dynamic process. When these activities are supported by tools based on artificial intelligence, conditions are created for adaptive and personalized learning, adapted to the individual needs and abilities of students. Such an approach encourages self-regulation, autonomy and responsibility in the learning process, but at the same time enables the development of algorithmic thinking as an important cognitive skill.

However, the integration of gamification and artificial intelligence in education is not without challenges. There are risks of superficial application of game elements, aimed at external rewards, as well as the danger of uncritical acceptance of algorithmic recommendations. Therefore, a carefully thought-out pedagogical approach is necessary that places technology as a function of the development of critical thinking, rather than as an end in itself.

In that context, the concept „from game to algorithm" emerges as a significant educational framework. It implies a gradual transition from learning through play to structured, logical, and algorithmic thinking, whereby students are introduced to the processes of analysis, planning, and decision-making through game activities. Starting from these observations, this paper aims to consider the integration of gamification and artificial intelligence as an innovative model for encouraging critical thinking among elementary school students, aligned with modern educational needs and values.

2. Literature review

2.1. Critical thinking in a digitally and algorithmically mediated educational context

Critical thinking is one of the central educational goals of modern education and is widely recognized as an essential competence for active, responsible, and ethically conscious participation in the knowledge society. Students today are not only faced with the need to acquire knowledge but also to question the sources, contexts, and intentions behind the information that is brought to them through digital media and intelligent platforms.

In the national education system, critical thinking is clearly defined as a key competence for lifelong learning. The Education Development Bureau (BRO, 2020) highlights it as an ability that develops through the active involvement of students in processes of analysis, argumentation, problem solving, decision making, and reflection. These processes imply the abandonment of traditional, reproductive learning models and a transition to teaching strategies that place the student at the center of the educational process.

In the digital environment, critical thinking is inextricably linked to media and digital literacy. The Agency for Audio and Audiovisual Media Services (AAVMU, 2021) indicates that students are exposed to a continuous flow of information, the selection and ranking of which is often done through algorithms that are not transparent to the user. This reality creates a need to develop a critical awareness of the way algorithms influence the perception of reality, the formation of attitudes, and decision-making.

The Macedonian Media Institute (2022) further emphasizes that critical thinking in the digital age cannot be considered in isolation from issues of media ethics, responsibility, and social impact. Students should be empowered not only to use digital tools technically but also to cognitively question their results, question the accuracy and objectivity of information, and develop an awareness of the limitations and biases of algorithmically generated content. In this context, critical thinking also acquires a clear value dimension. It is not only a cognitive skill, but it is the basis for the formation of an independent, responsible, and ethically aware person. This aspect is particularly significant because it considers education not only as a technical process, but also as a space for shaping the human personality and value system.

The integration of artificial intelligence in education further reinforces the need to develop critical thinking. Artificial intelligence works on the basis of complex algorithms and large databases, and its results are often perceived as objective and indisputable. According to UNESCO's recommendations for North Macedonia (2023), education should prepare students to be critical users of AI, capable of understanding the principles of its functioning and evaluating its results from an ethical, social, and educational perspective.

From a pedagogical point of view, the development of critical thinking requires the creation of teaching situations that activate higher cognitive levels – analysis, synthesis, and evaluation. Traditional frontal methods are insufficient to achieve these goals, especially in the digital educational environment. Therefore, modern teaching approaches are increasingly directed towards problem-oriented, research and interactive activities that encourage student autonomy and reflection (MES, 2021).

2.2. Gamification as a pedagogical mechanism for the development of critical and algorithmic thinking

Gamification in education is a modern pedagogical approach based on the integration of game-specific elements – rules, goals, challenges, feedback, and symbolic rewards – in teaching contexts with clearly defined educational goals. Unlike spontaneous play, gamification is developed as a structured didactic model, the purpose of which is to increase students' motivation, engagement, and cognitive activity.

In the Macedonian educational context, learning through play is particularly emphasized in primary education, where play is recognized as a natural way of learning and a means of developing cognitive, social, and emotional competencies (Ministry of Education, 2019). According to the guidelines of the Education Development Bureau (2020), gamified teaching activities create conditions for active participation of students, encourage an investigative spirit, and enable the development of critical and logical thinking.

The key pedagogical value of gamification lies not only in its motivational potential but also in its ability to structure student thinking. Through clearly defined rules and goals, the game creates a cognitive framework in which students begin to think systematically, plan steps, and predict the consequences of their choices. These processes represent the basis for the development of algorithmic thinking.

Research conducted within the pedagogical faculties in North Macedonia indicates that gamified activities enable a gradual transition from intuitive and experiential learning to organized and analytical thinking (Faculty of Pedagogy - Bitola, 2021). Through repeating game situations and solving problems within the game, students begin to recognize patterns, rules, and logical connections.

Within the concept of „From Game to Algorithm, the game appears as the initial catalyst of cognitive development. It creates a safe environment for experimentation, in which a mistake is not perceived as a failure, but as an opportunity for learning and reflection. This aspect is of particular importance for the development of critical thinking, as it encourages students to question their own strategies and assumptions. In addition, gamification enables the development of metacognitive skills, that is, awareness of one's own thought processes. When students think about why a particular strategy works or doesn't work, they move to higher cognitive levels, which is a key step in developing critical thinking.

2.3. From Game to Algorithm: Integration of Gamification and Artificial Intelligence

Algorithmic thinking is a key cognitive skill in modern society, which increasingly relies on digital and intelligent systems. Although traditionally associated with programming and informatics, contemporary pedagogical literature indicates that algorithmic thinking is a broader concept that includes the ability to logically structure problems, plan steps, and make decisions based on clear rules and conditions.

In the Macedonian educational context, the development of algorithmic thinking is in accordance with the strategic documents for the promotion of digital competences among students, emphasizing the need for the integration of innovative teaching approaches that connect technology and critical thinking (Ministry of Education and Science, 2021). In that process, the game is imposed as a natural and pedagogically justified starting point for the introduction of algorithmic principles.

Gamified activities create a context in which students intuitively adopt the basic elements of algorithmic thinking: sequence of steps, conditions, repetition and consequences. Through the game, students face problem situations that require planning, predicting, and correcting strategies. This process enables a gradual transition from experiential and intuitive learning to structured and systematic thinking, which is the essence of the concept „From Game to Algorithm".

In this context, algorithmic thinking does not develop in isolation, but is closely related to critical thinking. When students analyze why a particular strategy is successful or unsuccessful, they question their own assumptions, analyze results, and draw conclusions based on evidence. These cognitive processes directly contribute to the development of critical thinking, especially in contexts involving complex and dynamic situations.

The integration of artificial intelligence into gamified learning further deepens this process. AI tools enable adaptive learning by adjusting task difficulty, tracking student progress, and providing personalized feedback. In the Macedonian educational discourse, this approach is considered as an opportunity to improve the quality of teaching, but also as a challenge that requires the development of critical awareness among students (UNESCO North Macedonia, 2023).

From a pedagogical point of view, AI should not be used as an automated control or evaluation mechanism, but as a cognitive partner that supports the student in the thinking process. When students work with AI-supported gamified systems, they are faced with algorithmic decisions that can and should be subject to analysis and discussion. In this way, AI becomes a means of developing a critical awareness of the way intelligent systems work and of their potential limitations and biases (AAVMU, 2021).

In addition, such integration enables the development of metacognitive skills, as students receive feedback that directs them to self-reflection and correction of their own strategies. This process is consistent with the Bureau of Educational Development's recommendations for active and student-centered learning, which emphasizes the process, not just the result (BRO, 2020).

Hence, the integration of gamification and artificial intelligence can be seen as an innovative pedagogical model that connects experiential learning with algorithmic thinking and critical analysis. The concept „From game to algorithm" reflects exactly this evolution of student thinking – from game as a form of engagement, through algorithm as a cognitive structure, to a critical awareness of the role of technology in modern society.

2.4. Integrative model: game – algorithm – artificial intelligence – critical thinking

Contemporary pedagogical literature increasingly points to the need for integrative educational models that overcome fragmented approaches to learning and enable the connection of different cognitive, affective, and technological dimensions of the teaching process. In that context, the „game - algorithm - artificial intelligence - critical thinking" model represents a modern framework that connects natural student motivation with structured thinking and critical analysis of digital reality.

The game, as the starting point of the model, is recognized as a fundamental medium for learning, especially in primary education. It enables active participation, experimentation, and emotional involvement, creating a safe environment in which students are free to explore and make mistakes. Pedagogical research indicates that this kind of environment is a prerequisite for the development of higher cognitive processes, because through play, students spontaneously enter situations that require decision-making, planning, and assessment of consequences (Ministry of Education, 2019; BRO, 2020).

The algorithm, as the second component of the model, represents a cognitive structure that emerges from the gaming experience. Through repetition of game situations, students begin to recognize rules, patterns, and logical connections, which leads to the gradual formation of algorithmic thinking. In this context, the algorithm is not understood exclusively as a technical term related to programming, but as a way of thinking that implies breaking down problems into steps, predicting outcomes, and making systematic decisions (UKIM, 2020).

Artificial intelligence, as the third component of the integrative model, has a dual role: supporting and challenging. On the one hand, AI enables personalized and adaptive learning by analyzing student progress, adjusting tasks, and providing timely feedback. On the other hand, it represents an algorithmically mediated system that itself becomes an object of critical analysis. In an educational context, this opens up the opportunity for students not only to learn with the help of AI, but also to learn about AI – to understand its limitations, biases, and impact on decision-making (UNESCO North Macedonia, 2023; AAVMU, 2021).

Critical thinking emerges as an integrative result of the interaction between the game, the algorithm, and the artificial intelligence. In this model, students are not passive users of technology, but active subjects who analyze their own actions, question algorithmic solutions, and evaluate the results of digital systems. Critical thinking is developed through constant reflection, comparing alternative strategies, and making reasoned conclusions, which is in line with national educational priorities for the development of autonomous and responsible students (BRO, 2020).

The literature indicates that such an integrative approach is particularly relevant in a digitally and media-saturated environment, where students are daily confronted with algorithmically selected content. Through gamified and AI-supported activities, teaching can create conditions for students to develop an awareness of the way information is generated and mediated, as well as to build a critical distance towards digital authorities.

This model can also be seen as a value framework that connects technology with the educational mission of education. The integration of the game, algorithmic thinking, and artificial intelligence should not lead to a technocratic approach, but to the development of the person - a student who thinks, questions, and acts responsibly in the complex modern world. In that way, the „game - algorithm - AI - critical thinking" model is positioned as a pedagogical response to the challenges of the digital age, aligned with humanistic and educational values.

3. Research methodology

3.1 Research approach

This paper applies a qualitative research approach in order to explore the potential of the integration of gamification and artificial intelligence in fostering critical thinking among primary school students. As an appropriate methodological choice, a case study is used, which enables an in-depth consideration of a specific educational practice in its real context.

The choice of a case study is justified by the research objective of the paper, which is not aimed at generalization of the results, but at the analysis and interpretation of learning processes, student reactions, and pedagogical effects of the application of the „From Game to Algorithm“ model.

3.2. Context and participants

The case study was carried out as part of a teaching activity in a primary school, with students from grade school (age 9-10). The activity is carried out in a regular teaching context, as part of an integrated teaching unit related to the development of logical, algorithmic, and critical thinking.

Students with different levels of prior knowledge and digital competencies participated in the activity, which made it possible to see the impact of the gamified and AI-supported approach on different student profiles. The role of the teacher was that of a facilitator, who guided the students through questions, discussion, and reflection, without directly offering solutions.

3.3. Description of the teaching activity

The teaching activity was designed based on the conceptual model „From Game to Algorithm“ and took place in three successive stages.

Phase 1: Dramatized problem situation

The activity started with a gamified story in which the students played the role of „researchers“ who had to solve a series of challenges to reach the goal. The challenges were designed to require:

- planning of steps,
- choice between several possible strategies,
- predicting consequences of decisions.

In this phase, the emphasis was placed on experiential learning and active participation, without the explicit use of formal algorithmic concepts.

Phase 2: Algorithmic structure and reflection

After completing the game activities, the students were encouraged to analyze their actions through a guided discussion. The questions were aimed at:

- identification of the sequence of steps,
- recognition of rules and conditions,
- analysis of successful and unsuccessful strategies.

At this stage, students gradually began to structure their experiences in the form of simple algorithmic patterns (eg “first – then – if/then”), which represented a transition from play to algorithm.

Phase 3: AI-supported adaptation and critical analysis

In the final phase, students worked with a digital tool supported by artificial intelligence, which offered additional tasks with an adjustable level of difficulty and feedback. Students were encouraged to analyze the feedback and discuss it:

- why the system offers certain tasks,
- how the algorithm „decides“ the weight,
- Do they always agree with the proposed solutions?

This phase was crucial for developing a critical awareness of the functioning of algorithmic systems.

3.4. Data collection methods

Data were collected through:

- observation of student participation and interaction,
- analysis of student products (solutions, diagrams, algorithmic schemes),
- reflective discussion with the students after the activity.

These methods enabled a qualitative observation of changes in students‘ thinking, problem-solving strategies, and critical engagement.

The analysis of the collected data indicates several significant findings:

- Students showed increased motivation and engagement in the gamified environment.
- A gradual transition from intuitive to structured thinking has been noted.
- Students were able to explain and justify their choices, which indicates the development of critical thinking.
- Interaction with the AI tool prompted questions and discussions about the accuracy and logic of algorithmic decisions.

The results of the case study indicate that the conceptual model „From Game to Algorithm“ can be successfully applied in teaching practice, especially in primary education. The integration of gamification and artificial intelligence creates conditions for the development of critical, algorithmic, and digital thinking among students, which confirms the relevance of the proposed model.

4. Findings / results

Based on the research, the analysis of modern pedagogical approaches, and the consideration of practical examples from the teaching practice, several key findings can be made regarding the integration of gamification and artificial intelligence in order to encourage critical thinking among students.

First, it is clearly confirmed that gamification is an effective initial mechanism for students' cognitive activation. Literature and teaching practice indicate that students show a higher level of engagement, motivation, and persistence when they are involved in gamified activities. The game creates a safe and stimulating environment in which students are ready to experiment, take risks, and learn from their mistakes. This turns out to be particularly significant for the development of critical thinking, as error is experienced as a learning resource rather than a failure.

The second observation refers to the gradual transition from experiential to algorithmic thinking. The analyzed sources indicate that when the gamified activities are pedagogically designed and aimed at solving problems, students spontaneously begin to structure their actions, plan steps and predict the consequences of their own choices. This process is the basis for the development of algorithmic thinking, which is not limited to informatics, but manifests itself as a general cognitive skill applicable in all teaching subjects.

Third, the results indicate that the integration of artificial intelligence further deepens the cognitive process, especially when AI is used as a support rather than a substitute for pedagogical interaction. AI-supported systems enable the adaptation of tasks according to the individual abilities of students, timely feedback and monitoring of progress, which creates conditions for personalized learning. In such a context, students are encouraged to self-regulate, self-reflect and take responsibility for their own learning – key elements of critical thinking.

At the same time, it is stated that artificial intelligence represents a significant cognitive and ethical challenge. Algorithmically mediated content, recommendations and decisions should not be accepted uncritically. On the contrary, it is emphasized that the educational value of AI increases when it becomes the subject of analysis and discussion. Students who are encouraged to ask questions about how algorithms work, why the system offers certain solutions, and what its limitations are, develop a higher level of critical awareness and media literacy.

In addition, the analysis shows that the integrative model „game - algorithm - AI - critical thinking" enables a holistic approach to learning. Instead of fragmented introduction of technologies or isolated activities, this model creates a coherent educational framework in which each component has a clear pedagogical function. The game serves as motivational and experiential input, the algorithm as cognitive structure, AI as adaptive support, and critical thinking as the ultimate educational goal. In the context of the Macedonian educational system, these findings are in accordance with the guidelines for the development of digital, logical and critical competencies among students. In particular, the need for careful planning of teaching activities and professional preparation of teachers for the integration of such innovative models in daily practice is highlighted.

The results of the analysis indicate that the integration of gamification and artificial intelligence, when it is pedagogically designed and value oriented, has a significant potential for improving critical thinking among students. This approach not only contributes to the improvement of the quality of learning, but also creates a basis for the education of thinking, autonomous and responsible persons, capable of critically moving through the complex digital world - which is an essential mission of education.

5. Discussions and conclusions

The results of the conducted case study indicate that the integration of gamification and artificial intelligence in the teaching process has a significant potential for encouraging critical thinking among elementary school students. These findings are consistent with contemporary theoretical and research insights related to learning through play, the development of algorithmic thinking, and the role of artificial intelligence in education.

The observed increase in student motivation and engagement during gamified activities confirms the thesis that learning through play creates an emotionally and cognitively favorable learning environment. These results are consistent with the views of Deterding et al. (2011) and Kapp (2012), according to which gamification, through clearly defined goals, rules, and continuous feedback, strengthens internal motivation and encourages the active role of the student in the learning process.

In addition, Gee (2007) points out that quality educational games create „systems of meaning", in which students learn through experimentation, error-making, and reflection. Exactly such processes were also observed within the framework of this study, where the students, through the game, developed strategies, questioned their own decisions, and reasoned their actions. The game, in this context, was not only a motivational element but also a means of cognitive shaping and deepening of thought processes. One of the most significant findings of the research concerns the gradual transition from intuitive and experiential action to structured and logically organized thinking. Through targeted reflection and pedagogical guidance, students were able to formulate their activities in the form of sequences, rules, and conditions, which is the basis of algorithmic thinking. This process indicates the possibility to develop algorithmic concepts naturally and thoughtfully, through activities that are close and meaningful to the students.

This finding is consistent with the concept of computational thinking, as defined by Wing (2006), as the ability to solve problems through logical decomposition, pattern recognition, and systematic planning. Research by Grover and Pea (2013) further confirms that algorithmic thinking can be successfully developed in early education, especially when it is linked to concrete, contextualized, and meaningful activities. In the Macedonian educational context, this approach represents an opportunity to overcome traditional reproductive learning and to introduce students to the logic of the modern digital society in a developmental and acceptable way.

The interaction with the AI-supported tool in the third phase of the activity showed that students do not perceive technology exclusively as a source of correct and final answers, but as a system that can and should be analyzed, questioned, and evaluated. Students asked questions related to the logic of the algorithm, the choice of tasks, and the accuracy of the solutions offered, which indicates the development of a critical distance towards technology.

These observations are consistent with the views of Holmes et al. (2019) and UNESCO (2023), which emphasize that the educational application of artificial intelligence should be aimed at the development of critical and ethical awareness, and not only at the automation and optimization of learning. In this context, artificial intelligence functions as a cognitive challenge that encourages students to think about the way information is selected, structured, and interpreted, which is especially significant in the era of algorithmically mediated reality.

The results of the study clearly show that critical thinking does not develop in isolation, but as a result of the interaction between the game, algorithmic structure, and technological support. Students demonstrated abilities for analysis, argumentation, and self-reflection, which is consistent with definitions of critical thinking provided by Facione (2011) as well as Paul and Elder (2006). Additionally, the findings are aligned with the European Digital Competence Framework (DigComp 2.1), which emphasizes the importance of critical and responsible use of technology.

From the perspective of educational policies, the results indicate that the integration of gamification and artificial intelligence is not only a pedagogical innovation but also a strategic opportunity for the advancement of teaching practice. The conceptual model „From Game to Algorithm“ offers a framework for the systematic development of critical, algorithmic, and digital thinking, in accordance with contemporary social and technological challenges. In that direction, the need for curricular reforms that will recognize critical thinking as a transversal competence and not as an isolated educational outcome is emphasized. In terms of teaching practice, the study points to the key role of the teacher as a facilitator of learning, who guides students through the process of play and experience, through structured thinking, to critical analysis of technological tools. Played activities create space for dialogue, reflection, and differentiated learning, whereby individual differences between students are recognized as a resource, not as an obstacle.

As a synthesis of pedagogical, technological, and cognitive aspects of learning, the „From Game to Algorithm“ model represents a flexible and adaptable approach with the potential for application in various educational contexts. Its application can contribute to building an educational system that not only follows technological innovations but also critically examines them, putting the student at the center of the learning and development process.

6. Limitations and directions for future research

This paper explores the integration of gamification and artificial intelligence as a contemporary pedagogical approach to encourage critical thinking in primary school students. Starting from the theoretical settings of learning through play, algorithmic thinking and critical digital literacy, the conceptual model „From Game to Algorithm“ was proposed and analyzed, which connects experiential learning, structured cognitive shaping and critical analysis of technological systems.

The results of the conducted case study indicate that gamified activities, when carefully designed and pedagogically guided, create an environment that significantly increases student motivation, engagement and readiness for active participation in the teaching process. The transition from a game to an algorithm allows students to gradually design and structure their own activities, while developing the basics of algorithmic and logical thinking. In addition, the use of artificial intelligence as an educational tool has proven to be a significant factor in fostering critical awareness, as students do not remain mere users of technology, but are encouraged to analyze, question and evaluate its role and impact.

One of the key conclusions of the research is that critical thinking does not develop in isolation, but as a result of the dynamic interaction between game experience, cognitive structure and technological mediation. In that context, the „From Game to Algorithm“ model stands out as a pedagogically sustainable and flexible approach, with the potential for application and adaptation in different teaching subjects and educational contexts.

Although the study has certain limitations related to its qualitative character and limited coverage, it offers significant insights into the potential of integrated pedagogical approaches in contemporary education. The research opens the need for further, more extensive and systematic research that will allow a deeper understanding of the long-term effects of the application of gamification and artificial intelligence on the development of critical and algorithmic thinking among students.

In that direction, future research could focus on:

- implementing quantitative and mixed research designs to measure the impact of the model on different aspects of student thinking;
- analysis of the application of the „From Game to Algorithm" model in different teaching subjects and educational levels;
- research of teachers' perceptions, competencies and readiness for the integration of gamification and artificial intelligence;
- examination of the ethical, social and educational aspects of the use of artificial intelligence in teaching;
- development and evaluation of digital tools specifically designed to support students' critical thinking.

In a broader perspective, such research can contribute to building an educational practice that not only follows technological innovations, but also critically shapes them, putting the student at the center of the learning process. Thus, the paper positions itself as a relevant contribution to contemporary discussions on the role of gamification and artificial intelligence in education, offering theoretical and practical guidelines for the development of critical, responsible and thoughtful learning in the digital age.

7. References

1. "Artificial Intelligence in Education: Promises and Implications for Teaching and Learning" edited by David Lynch, Council of Europe, November 2022
2. The power of artificial intelligence fascinates, but also frightens - Mirjana Joveska, February, 2023 https://mk.bloombergadria.com/tehnologija/inovacii/21186/mokjta-na-vestackatainteligencija-voodusevuva-no-i-zaplasuva/news
3. Why we need the psychology of artificial intelligence - Vladimir Davchev, Skopje, 2019
4. http://periodica.fzf.ukim.edu.mk/psnp/psnp5(2019)/PsNP05-06.04%20Davchev,%20V.pdf
5. What to expect in the era of artificial intelligence with ChatGPT? – January, 2023, https://factor. mk/shto-ne-ochekuva-vo-erata-na-veshtachkata-intelligencija-so-chatgpt
6. Artificial Intelligence, Global Edition, A Modern Approach - Stuart Russell, Peter Norvig, 2021 https://elibrary.pearson.de/book/99.150005/9781292401171#item-1
7. Teaching Machines: Learning from the Intersection of Education and Technology (Tech.edu: A Hopkins Series on Education and Technology) Illustrated Edition - Bill Ferster, https://www.amazon.com/ Teaching-Machines-Intersection-Education-Technology/dp/1421415402
8. Intelligent Tutoring Systems: How AI Can Improve Student Learning - Adrien Beaulieu, 2023, https://product.house/intelligent-tutoring-systems-how-ai-can-improve-student-learning/

9. The role of artificial intelligence in shaping the future of education: the potential and challenges of the new era of learning - March. 2023, https://www.alltechbuzz.net/mk/the-role-of-ai-in-shaping-the-future-of-education-the-potential-and-challenges-of-the-new-learning-era/
10. Artificial intelligence is of great benefit to students - Dorina Stefanovska, March, 2022, https://goce.mk/veshtachkata-inteligenczi%D1%98a-od-golema-korist-za-studentite/
11. Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.
12. Dewey, J. (1933). How we think: A restatement of the relation of reflective thinking to the educative process. D.C. Heath and Company.
13. Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification." Proceedings of the 15th International Academic MindTrek Conference, 9–15.
14. Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.
15. Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. Educational Psychologist, 50(4), 258–283.

ABOUT THE AUTHOR

MAJA MITEVSKA-POCEVA

Maja Mitevska-Poceva is a class teacher and mentor teacher at the Primary School 'Brakja Miladinovci' in Probištip, North Macedonia. She has worked for two years on a UNICEF project for educating mothers from rural areas. She has been a coordinator and trainer for major projects, such as language literacy in primary grades, interethnic integration, media literacy, coordinator for implementing the international TIMSS study, trainer for experiential learning on the environment and climate change, coordinator of a media club, editor of the school newspaper, etc. In 2018/2019, she was chosen as Teacher of the Year. In 2020, she obtained the title of Mentor Teacher, and in 2025, she was declared an "Education Worker of the 2024/2025 Academic Year" in the Republic of North Macedonia, as well as "The best teacher in the region". She is the author of several papers in domestic and international publications in the field of education. She has participated in a large number of seminars, congresses, symposiums, and conferences.