

INFORMATION AND COMMUNICATION TECHNOLOGIES IN EDUCATION

UDC 37.02:004.738.5:159.923:796.33

DOI <https://doi.org/10.5281/zenodo.19367590>

Adaptive Intelligent Platforms for Personalizing Cognitive Load in Inclusive Chess Environments

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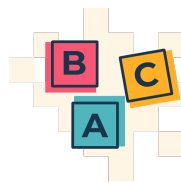
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Accepted: 14.03.2026 | Published: 30.03.2026

Abstract. *The contemporary development of digital technologies and the expansion of inclusive education necessitate the creation of intelligent educational environments capable of adapting the learning process to the individual cognitive capacities of learners. The use of game-based and intellectual practices, in particular chess, is highly relevant, as it promotes the development of logical thinking, concentration, and analytical abilities. In the context of inclusive education, the regulation of cognitive load is essential, since its mismatch may reduce the effectiveness of knowledge acquisition and learning motivation. **The aim of the study** is to substantiate the potential of adaptive intelligent platforms for the personalization of cognitive load in inclusive chess-based educational environments and to determine their capacity to enhance learning effectiveness.*

Methods. *The study employs analysis and synthesis of scientific literature on inclusive education, digital educational technologies, and cognitive load theory.*

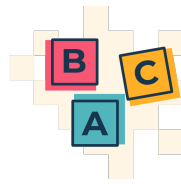


Systemic and comparative approaches are used to identify the specific features of digital tools applied in chess education. Theoretical modeling enables the identification of the potential of adaptive algorithms for personalizing learning tasks in accordance with the individual cognitive characteristics of users.

Results. *It is established that the application of adaptive intelligent platforms in chess-based educational environments provides flexible regulation of task complexity, learning pace, and the volume of instructional content. This contributes to the optimization of cognitive load and increases the effectiveness of learning activities. The integration of artificial intelligence elements, learning analytics systems, and personalized recommendations enables the formation of individual educational trajectories that take into account learners' levels of preparation and educational needs. The use of chess tasks in combination with adaptive digital tools supports the development of logical thinking, strategic planning, and decision-making skills.*

Conclusions. *Adaptive intelligent platforms demonstrate significant potential for the personalization of cognitive load in the process of learning chess within an inclusive educational environment. Their application enhances the effectiveness of the educational process, supports the formation of individual learning trajectories, and fosters the development of cognitive and analytical abilities among learners. Further research should focus on the development of models for integrating adaptive artificial intelligence algorithms into digital educational platforms.*

Keywords: *digital learning, educational technologies, artificial intelligence in education, individual learning trajectory, gamification of learning, logical thinking, digital educational tools.*



Адаптивні інтелектуальні платформи для персоналізації когнітивного навантаження в інклюзивних шахових середовищах

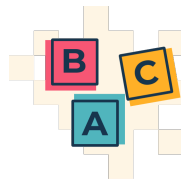
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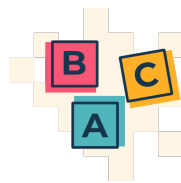
Анотація: Сучасний розвиток цифрових технологій і поширення інклюзивної освіти зумовлюють необхідність створення інтелектуальних освітніх середовищ, здатних адаптувати навчальний процес до індивідуальних когнітивних можливостей здобувачів освіти. Актуальним є використання ігрових та інтелектуальних практик, зокрема шахів, які сприяють розвитку логічного мислення, концентрації уваги та аналітичних здібностей. У контексті інклюзивного навчання важливим є регулювання рівня когнітивного навантаження, оскільки його невідповідність може знижувати ефективність засвоєння знань і навчальну мотивацію. **Метою дослідження** є обґрунтування можливостей використання адаптивних інтелектуальних платформ для персоналізації когнітивного навантаження в інклюзивних шахових освітніх середовищах та визначення їхнього потенціалу для підвищення ефективності навчання. **Методи.** У дослідженні застосовано аналіз та узагальнення наукової літератури з проблем інклюзивної освіти, цифрових освітніх технологій і теорії когнітивного навантаження. Використано системний і порівняльний підходи для визначення особливостей використання цифрових інструментів у навчанні шахів. Теоретичне моделювання дозволило окреслити можливості адаптивних алгоритмів для персоналізації навчальних завдань відповідно до індивідуальних когнітивних характеристик користувачів. **Результати.** Встановлено, що застосування



*адаптивних інтелектуальних платформ у шахових освітніх середовищах забезпечує гнучке регулювання складності завдань, темпу навчання та обсягу навчальної інформації. Це сприяє оптимізації когнітивного навантаження та підвищує ефективність навчальної діяльності. Інтеграція елементів штучного інтелекту, систем аналізу навчальних дій і персоналізованих рекомендацій дає змогу формувати індивідуальні освітні траєкторії з урахуванням рівня підготовки та навчальних потреб здобувачів освіти. Використання шахових завдань у поєднанні з адаптивними цифровими інструментами сприяє розвитку логічного мислення, стратегічного планування та навичок прийняття рішень. **Висновки.** Адаптивні інтелектуальні платформи мають значний потенціал для персоналізації когнітивного навантаження в процесі навчання шахів в інклюзивному освітньому середовищі. Їх застосування сприяє підвищенню ефективності освітнього процесу, формуванню індивідуальних навчальних траєкторій та розвитку когнітивних і аналітичних здібностей здобувачів освіти. Подальші дослідження доцільно спрямувати на розробку моделей інтеграції адаптивних алгоритмів штучного інтелекту в цифрові освітні платформи.*

***Ключові слова:** цифрове навчання, освітні технології, штучний інтелект в освіті, індивідуальна освітня траєкторія, гейміфікація навчання, логічне мислення, цифрові освітні інструменти.*

Introduction. The contemporary development of education is accompanied by the active integration of digital technologies and the expansion of inclusive learning practices, which necessitates the creation of educational environments capable of accommodating the individual characteristics of learners. Under these conditions, the use of digital tools becomes particularly significant, as they enable the adaptation of the learning process to diverse cognitive capacities of students, ensuring accessibility and effectiveness of education for a broad range of users. One



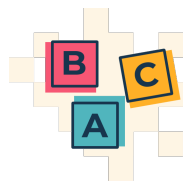
of the promising directions in this context is the application of intelligent and game-based practices, in particular chess, which facilitates the development of logical thinking, concentration, analytical abilities, and strategic planning skills.

At the same time, the effectiveness of the educational process largely depends on the level of cognitive load that arises during the performance of learning tasks. Excessive load may lead to fatigue, reduced motivation, and decreased learning outcomes, whereas an insufficient level of complexity does not stimulate cognitive engagement. In the context of inclusive education, this issue becomes particularly relevant, as learners may differ in their level of preparation, pace of information acquisition, and individual characteristics of cognitive functioning.

In this regard, there is a growing interest in the use of adaptive digital systems capable of automatically regulating task complexity, the pace of content delivery, and the volume of information in accordance with user needs. Contemporary intelligent platforms that employ artificial intelligence algorithms and learning analytics provide new opportunities for the formation of individualized learning trajectories and the optimization of the educational process.

Therefore, the study of the potential for using adaptive intelligent platforms to personalize cognitive load in inclusive chess-based educational environments represents a relevant task for contemporary pedagogical science and practice, requiring comprehensive theoretical understanding and further scholarly development.

Literature Review. In the current context of educational technology development, adaptive learning and the personalization of the educational process have gained particular importance, as they enable the formation of individual learning trajectories for students. The findings of recent studies highlight various aspects of this issue, including the application of innovative technologies, gamification, and inclusive education.



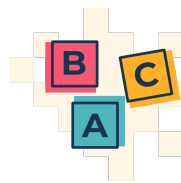
Pryzvanska R., H. Poplavska, and N. Uholkova examine the psychosocial characteristics of children with autism, which constitute an important foundation for the development of adaptive educational environments that account for cognitive load [1]. The effectiveness of therapeutic and sensory approaches in working with children with special educational needs is substantiated by R. Pryzvanska [2], which underscores the necessity of personalizing educational content. At the same time, T. Stetsenko investigates the potential of artificial intelligence for predicting individual responses, thereby opening prospects for the use of intelligent systems in adapting educational processes [3].

The application of contemporary learning platforms and information systems for the personalization of the educational process is examined by Ya. Sikora [4], V. Miziuk and co-authors [5], as well as T. Serdenko and T. Reis [6].

In the context of inclusive education, Ya. Chyhryna [7] and M. Diachenko and colleagues [8] analyze the potential of implementing innovative technologies to ensure accessibility of learning for students with special educational needs, emphasizing the necessity of combining digital platforms with adaptive methodologies to create a supportive educational environment.

One of the relevant directions is the application of gamification and computer technologies in the educational process. Shankovskyi A. and co-authors investigate the development of computer technologies in chess, which enables the formation of strategic and logical thinking [9], while Sharan O. and colleagues analyze the use of gamification in the New Ukrainian School to enhance learner motivation and engagement [10].

An important aspect is the formation of an adaptive digital environment in educational institutions. In particular, T. Vdovychyn and colleagues [11] and Yu. Ribtsun and co-authors [12] demonstrate that the comprehensive implementation of digital platforms and personalization technologies contributes to improving the quality of education and the development of individual learning



trajectories. The role of artificial intelligence in the implementation of adaptive learning in professional pre-higher education, which opens new prospects for integrating digital methodologies into pedagogical practice, is emphasized by R. Medvediev [13; 14].

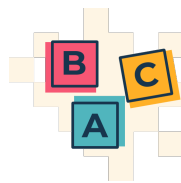
At the same time, previous studies do not encompass a comprehensive integration of all components of adaptive learning with consideration of inclusion and gamification in general and professional educational institutions.

Identification of previously unresolved aspects of the general problem.

Despite the active development of digital educational technologies and the growing interest in inclusive learning, a number of aspects related to the use of intelligent educational systems remain insufficiently explored. In particular, the issue of effective regulation of cognitive load under conditions of using digital learning tools requires further scholarly investigation. In most contemporary educational platforms, the complexity of learning tasks and the pace of content delivery remain fixed or are only partially adapted to individual user needs, which may reduce the effectiveness of the educational process.

This problem is particularly relevant in inclusive educational environments, where learners may differ in their level of preparation, the pace of information perception, and individual cognitive characteristics. Traditional teaching methods and most existing digital resources are not always capable of ensuring an optimal balance between the complexity of learning tasks and the cognitive capacities of users. As a result, some learners may experience cognitive overload, while others, conversely, do not receive a sufficient level of intellectual stimulation.

Particular attention should be paid to the issue of grouping children with different levels of chess proficiency within the same class. Traditional approaches involve dividing students by level, which complicates the organization of inclusive learning. The development of adaptive methods remains relevant, as these methods allow stronger students to play against weaker ones by providing handicaps, as well



as the use of tasks of varying complexity from digital chess platforms such as Gambitus, ChessMatec, Chess Adventure, Chess Universe, Lichess Learning, and Chess.com. This approach enables the formation of unified groups in which all students receive an intellectual challenge appropriate to their level of preparation. At the same time, the integration of such approaches into curricula and the evaluation of their effectiveness remain insufficiently studied.

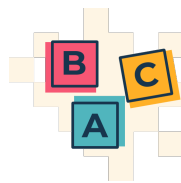
In addition, contemporary research does not sufficiently address the use of artificial intelligence systems and learning analytics for the formation of individual educational trajectories in the process of learning intellectual games. The integration of such technologies, however, may contribute to improving the effectiveness of the educational process and to creating more flexible learning environments oriented toward the needs of each user.

Therefore, an important scientific task is to investigate the potential of adaptive intelligent platforms for regulating cognitive load in inclusive chess-based educational environments. This will enable the integration of the potential of intellectual games with contemporary digital technologies and contribute to enhancing learning effectiveness. The present article is aimed at a comprehensive analysis and the implementation of adaptive technologies across various educational contexts.

Purpose of the article (problem statement). The aim of the study is to provide a theoretical substantiation and analysis of methods for using adaptive intelligent platforms to integrate learners with different levels of chess proficiency into a single group and to optimize cognitive load.

The objectives of the study are as follows:

1. to analyze digital chess platforms (Gambitus, ChessMatec, Chess Adventure, Chess Universe, Lichess Learning, Chess.com) in terms of their capacity for personalizing learning tasks;



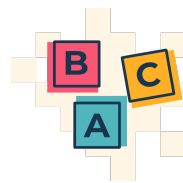
2. to examine methods for applying handicaps and differentiated tasks of varying complexity for learners with different levels of preparation;
3. to investigate combined instructional approaches based on the use of adaptive tasks on digital platforms;
4. to develop a structural and functional framework for organizing inclusive chess education through the use of handicaps and adaptive digital platforms.

The implementation of these objectives will contribute to a deeper scientific understanding of the use of adaptive digital technologies in the educational process and to identifying prospects for their application in inclusive educational environments.

Results of the study. Inclusive education in the contemporary educational environment involves creating conditions for learning for all students, regardless of their individual abilities and level of preparation. In the context of chess education, this implies ensuring access to intellectual games and exercises for learners with different levels of experience, while each student should receive an appropriate stimulus for the development of logical thinking, concentration, and strategic planning.

In the process of forming mixed chess groups, it is necessary to take into account differences in the level of learners' preparation. Practice demonstrates that rigid differentiation by levels is not sufficiently effective, as participants with lower levels of preparation may experience isolation, while more advanced learners do not receive an adequate level of intellectual challenge. In this regard, one of the key tasks in organizing inclusive chess education is to create an educational environment in which learners with different levels of preparation can interact while receiving differentiated tasks and appropriate opportunities for intellectual development.

The theoretical substantiation of the personalization of cognitive load in chess education is based on the principles of adaptive learning, which involve selecting



tasks in accordance with the individual capabilities of learners. The formation of individual learning trajectories contributes to the development of cognitive abilities and supports learning motivation. Adaptive platforms provide opportunities for remotely adjusting task complexity in accordance with the pace of content acquisition. Information systems for learning personalization enhance the effectiveness of the educational process and contribute to the development of individual competencies [3, p. 1791].

In contemporary chess education, digital platforms have become widely used, enabling the adaptation of tasks in accordance with learners' levels of preparation and their individual needs. Such tools not only enhance the effectiveness of the educational process but also facilitate the integration of learners with different levels of chess skills into unified groups.

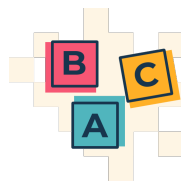
Among the most popular platforms are Gambitus, ChessMatec, Chess Adventure, Chess Universe, Lichess Learning, and Chess.com. Each of these offers various opportunities for the personalization of learning, including the adaptation of task complexity, the use of instructional scenarios and training exercises, as well as the integration of game-based elements to increase motivation.

A comparison of the main characteristics of digital chess platforms is presented in Table 1.

Table 1

Comparative characteristics of digital chess platforms in terms of learning personalization and the integration of learners with different levels of preparation

Platform	Level of adaptivity	Interface	Advantages	Limitations
Gambitus	Medium	Intuitive	Simplicity of tasks, possibility of handicaps	Limited range of activities
ChessMatec	High	Bright, child-oriented	Built-in trainers, adaptive exercises	Limited tournament options
Chess Adventure	Medium	Interactive	Diverse scenarios, narrative-based lessons	Limited number of advanced tasks



Chess Universe	High	Modern, user-friendly	Personalized tasks, AI-based recommendations	Requires stable internet connection
Lichess Learning	High	Minimalist	Extensive exercise base, error analysis	Fewer game-based elements for children
Chess.com	High	Convenient, adaptive	Interactive tasks, handicaps for stronger players	Premium features are partially paid

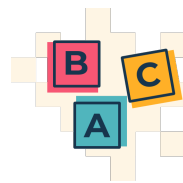
Source: developed by the author based on [1; 3; 6]

The analysis indicates that platforms with a high level of adaptivity, in particular ChessMatec, Chess Universe, Lichess Learning, and Chess.com, are more effective for personalizing the educational process and integrating learners with different levels of preparation. They provide opportunities for the differentiation of learning tasks, where more advanced learners engage with higher complexity tasks, while others work with tasks that correspond to their cognitive capacities, which contributes to balancing cognitive load within a shared group.

The limitations of most platforms include dependence on a stable internet connection, the presence of partially paid functionality, and a limited range of instructional scenarios for different age groups. At the same time, their advantages are substantial, including support for adaptive learning, increased motivation through gamification elements, as well as the possibility of systematic monitoring of results and the formation of individual learning trajectories.

Overall, the review of digital chess platforms demonstrates their significant potential for organizing inclusive learning. Platforms with well-developed adaptive and gamification mechanisms enable the effective integration of learners with different levels of preparation within a shared educational environment, promoting the development of logical thinking, concentration, and strategic planning skills.

In organizing inclusive chess education, it is necessary to consider differences in learners' levels of preparation in order to ensure effective participation for each individual. One effective approach is the use of handicaps during games between more advanced and less advanced participants, which contributes to creating



balanced conditions and maintaining motivation across different levels of preparation. Handicaps may be implemented by providing additional pieces, increasing thinking time, or introducing specific constraints for stronger players, which ensures an optimal cognitive load and supports the development of strategic thinking (Table 2).

Table 2

Methods for applying handicaps for learners with different levels of chess proficiency

Learner level	Handicap in the game	Purpose	Expected effect
Low	Additional pieces	To stimulate participation	Increased motivation, development of strategic thinking
Intermediate	Additional time per move	To balance the pace of the game	Development of concentration, move planning
Advanced	Standard conditions	Challenge and skill improvement	Enhancement of analytical abilities and strategic thinking

Source: developed by the author based on [4; 5; 6; 12]

Alongside handicap-based play, an important element is the selection and design of tasks of varying complexity for learners grouped within a shared environment. Adaptive digital chess platforms such as Gambitus, ChessMatec, Chess Adventure, Chess Universe, Lichess Learning, and Chess.com provide opportunities for the automatic selection of exercises in accordance with the individual characteristics of learners. This makes it possible to organize combined learning activities that integrate individual exercises, paired or group games, and collective analysis of positions. Such an approach ensures the optimization of cognitive load and creates conditions for the development of logical thinking, concentration, and analytical abilities among participants (Table 2).

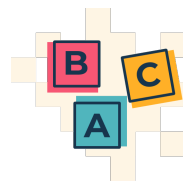


Table 3

Combined instructional methods with adaptive tasks on digital platforms

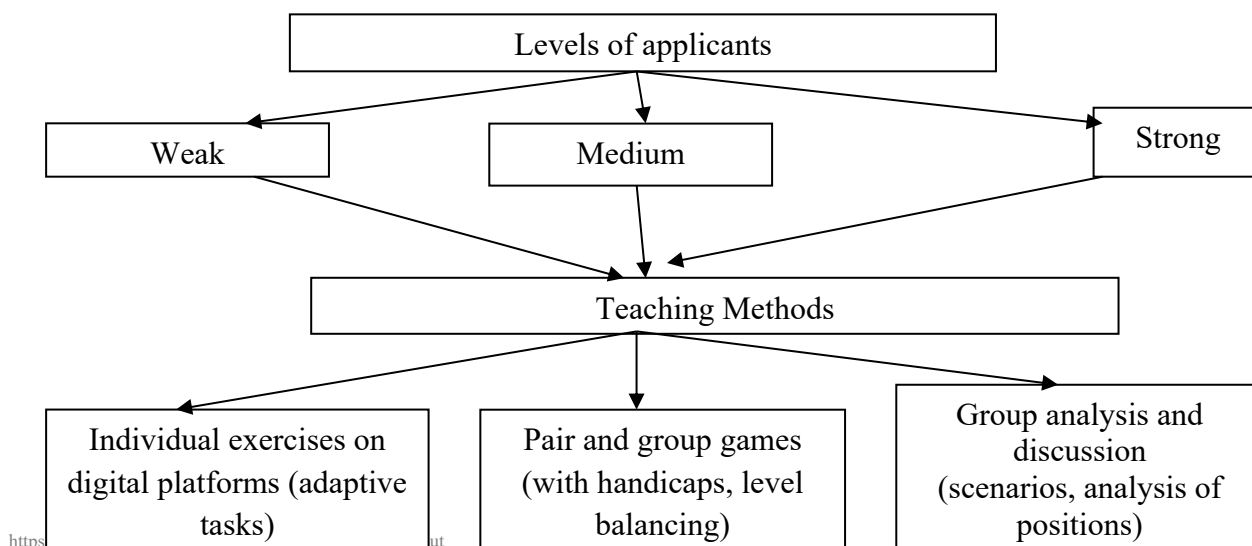
Type of activity	Tool/platform	Task adaptation	Forms of work	Expected effect
Individual work	ChessMatec, Lichess Learning	Automatic task selection based on rating	Individual exercises	Optimal cognitive load
Pair/group work	Chess.com, Chess Universe	Selection of tasks of varying complexity	Pair games, tournaments	Development of communicative and analytical skills
Collective analysis	Gambitus, Chess Adventure	Discussion of move variations	Group discussion, position analysis	Enhanced strategic thinking, critical analysis

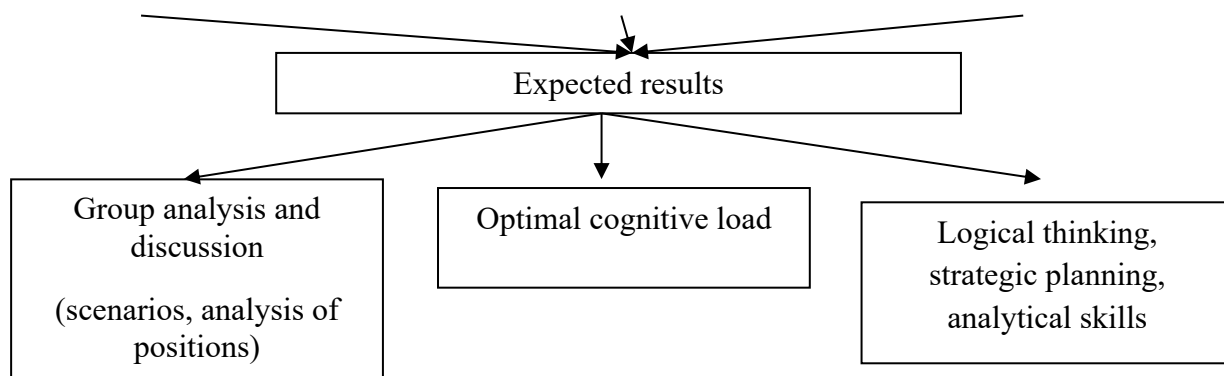
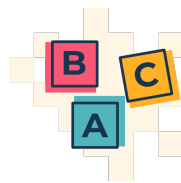
Source: developed by the author based on [13–16]

In addition, to provide a clear representation of the organization of inclusive chess education, it is advisable to use a schematic depiction of the interrelation between instructional methods and learners' levels of preparation. Figure 1 illustrates how individual, group, and collective components of learning interact, forming a system that supports individualized learning trajectories and ensures a level of cognitive load appropriate to the abilities of each learner.

Figure 1

Organization of Inclusive Chess Education Using Handicaps and Adaptive Digital Platforms



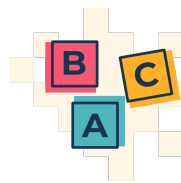


Source: developed by the author

Thus, the combination of handicap-based play, differentiated tasks on digital platforms, and collective analysis of positions enables the effective integration of learners with different levels of chess proficiency within a single group, promoting the development of logical thinking, strategic planning, and analytical skills.

Adaptive algorithms integrated into contemporary digital chess platforms ensure the individualization of the learning process in accordance with the needs of each learner. They analyze task performance results, decision-making speed, and the effectiveness of strategic thinking, generating personalized recommendations. This enables the selection of tasks with an optimal level of complexity, maintaining a balance between skill development and the prevention of cognitive overload [2].

Adaptation mechanisms involve the formation of individual learning trajectories that take into account the level of preparation, the pace of content acquisition, and the cognitive characteristics of learners. Less prepared participants work with basic tasks accompanied by explanations of strategies, while more advanced learners engage with higher complexity tasks aimed at anticipating opponents' moves and developing analytical thinking. This ensures a combination of individual and group forms of work and contributes to harmonious intellectual development [6, p. 336].

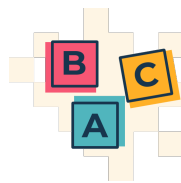


The integration of analytical tools and AI-based recommendations allows instructors to conduct real-time monitoring of learners' progress and to adjust the educational process accordingly. This approach creates equal conditions for all participants regardless of their initial level of preparation, increases learning motivation, and supports the development of logical, strategic, and analytical thinking. In addition, the use of AI technologies provides opportunities for improving digital platforms and developing more flexible approaches to the individualization of learning [8, p. 109].

The analysis of the implementation of the adaptive approach demonstrated that integrating learners with different levels of preparation into a shared group significantly enhances learning effectiveness. The use of digital platforms with adaptive algorithms supports the development of logical thinking, concentration, and strategic skills, as each participant works with tasks appropriate to their level. Observations indicate that learners acquire material more rapidly, while less prepared participants become more actively engaged in group activities without experiencing frustration.

A comparison between the traditional approach, in which all learners perform identical tasks, and the adaptive approach revealed a substantial advantage of the latter in terms of learning outcomes. Adaptive platforms ensure the personalization of cognitive load, which reduces the likelihood of fatigue and supports the consistent development of strategic thinking. At the same time, more advanced learners receive tasks of an appropriate level of complexity, enabling continuous improvement in move planning and the anticipation of game progression [9, p. 509].

The implementation of the adaptive approach also confirmed the hypothesis that personalized learning enhances the effectiveness of interaction among learners within a group and increases overall academic performance. Observational data show that learners who studied using adaptive platforms demonstrate higher



achievement in logical and strategic tasks compared to those who followed a traditional model.

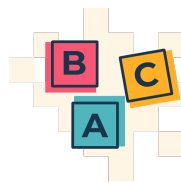
The results of the study confirm the scientific validity of applying adaptive methods in chess education. Adaptive algorithms and integrated artificial intelligence systems enable the formation of individual learning trajectories, support learner motivation, and ensure equal conditions for all participants regardless of their initial level of preparation. This is particularly important in inclusive groups, where joint learning among participants with different skill levels requires a flexible approach.

In this regard, coaches and educators are recommended to use adaptive platforms for lesson planning and progress monitoring, to combine individual and group work, and to select tasks in accordance with learners' levels of preparation. Particular attention should be given to the integration of AI-based analytics, which makes it possible to promptly adjust the educational process and enhance its effectiveness.

At the same time, it should be noted that most contemporary platforms do not yet provide comprehensive real-time analytics of learner behavior and require further evaluation of their impact on long-term learning outcomes. In this context, promising directions for future research include improving adaptation algorithms, integrating more comprehensive analytics, and examining the impact of personalization on the development of learners' cognitive, analytical, and strategic skills [12, p. 82].

Thus, the combination of adaptive technologies, artificial intelligence systems, and differentiated instructional approaches creates a foundation for the effective organization of inclusive chess education, ensuring personalization, motivation, and equal opportunities for all learners.

Conclusions. The conducted study confirms that adaptive intelligent platforms have significant potential for enhancing the effectiveness of learning in



inclusive chess-based educational environments. They ensure the personalization of cognitive load by regulating task complexity, the pace of content delivery, and the volume of instructional information in accordance with the individual characteristics of learners. The integration of artificial intelligence elements and analytical systems enables the formation of individual learning trajectories, stimulates the development of logical, strategic, and analytical thinking, and creates equal conditions for all participants in the educational process.

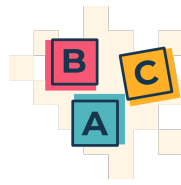
The study also demonstrates that integrating learners with different levels of preparation into a shared group through adaptive methods and digital platforms promotes more effective interaction and active participation of all learners. The application of handicaps, differentiated tasks, and combined instructional approaches makes it possible to avoid cognitive overload among less prepared participants while simultaneously providing an intellectual challenge for more advanced learners, which increases learning motivation and supports the development of cognitive skills within an inclusive group.

It has been determined that contemporary platforms require further improvement in the area of comprehensive analytics and in the assessment of the impact of adaptive algorithms on long-term learning outcomes.

Future research should focus on the integration of more flexible artificial intelligence models, the expansion of personalization capabilities, and the investigation of the effectiveness of adaptive methodologies in various educational contexts. Overall, the results confirm the feasibility of applying adaptive intelligent platforms to create an inclusive, motivating, and productive educational environment.

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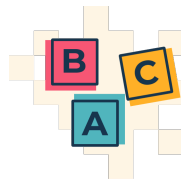
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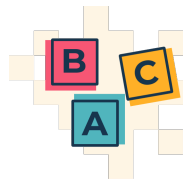
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