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GAME TECHNOLOGIES IN THE PROCESS OF TEACHING MATHEMATICS TO PRIMARY SCHOOL STUDENTS: AN ERGONOMIC DIMENSION

The article highlights some theoretical aspects of the usage of game technologies in primary school. The expediency has been determined and the range of target orientations of game technologies in the process of teaching mathematics to primary school students has been considered. Features of game activity in the modern educational environment of primary school are characterized. Ergonomic pedagogical conditions for the effective usage of didactic games in the process of learning the mathematical educational field are outlined. They are the following: taking into account the cognitive features of the education of students of the digital generation in the content of the structural components of didactic games; the use of inter-subject connections, with the aim of focusing didactic games on students' mastery of generalized techniques of cognitive activity; ensuring children's functional comfort in the process of game activities.

Keywords: *primary school, educational game technologies, didactic game, mathematical educational field, pedagogical conditions, effectiveness, educational process.*

Problem statement. The current state of Ukrainian society demands that education forms an innovative, active, and creative individual capable of independent thinking, critically analyzing information, making decisions, problem-solving, and collaborating with others. These skills are essential for success in the modern world. Primary education forms the foundation for developing these qualities. Primary school children explore the world, experiment, and nurture their imagination. Therefore, the initial stage of education holds significant importance for a child's future success.

The concept of the New Ukrainian School aims for the comprehensive development of individuals capable of creative and

intellectual activity, forming human qualities, and public opinion (*Концепція «Нова українська школа»,* 2016). This concept holds particular relevance in primary education, which aims for the holistic development of a child, their talents, abilities, competencies, and cross-cutting skills in accordance with their age and individual psychophysiological characteristics, fostering independence, creativity, and curiosity (*Про затвердження Державного стандарту…,* 2018).

To achieve this goal, primary school teachers are increasingly turning to innovative methods of psycho-pedagogical interaction among educational stakeholders, particularly by using various game-based learning technologies as a form of interaction. This approach involves the assimilation of educational content, attainment of desired learning outcomes, and encompasses a wide array of methods and techniques to organize the educational process.

Analysis of recent research and publications. The significance of game technologies in education and didactic considerations regarding their application have been explored by Sh. Amonashvili, V. Bespalko, L. Vygotsky, A. Makarenko, V. Sukhomlynsky, S. Shatsky, and others.

V. Sukhomlynsky (1977) wrote: “Game is a vast bright window through which a lively stream of a child’s ideas and understanding of the surrounding world flows into their spiritual realm. Game is the spark that ignites the fire of curiosity” (p. 95). The prominent educator pointed out that during play activities, both the mental processes of a student – thinking, speech, memory, attention – and essential personal qualities such as initiative, perseverance, concentration, and organization are developed.

Important aspects of the issue of using game technologies in primary school are addressed in the publications by N. Alendar (2017), S. Linkevych (2019), O. Savchenko (2012), and others.

Academician O. Savchenko (2012) emphasizes the significance of merging play with educational activities in primary classes, “when the complex transition from preschool childhood to school brings about a gradual shift from dominant forms of activity – from game one to educational one” (p. 305). The scholar notes, “to manage play activities, to fully reveal their educational and developmental potential, one needs to understand their structure and consider the individual and age peculiarities of children” (p. 306).

The close connection of didactic game with the educational process in mathematics lessons is highlighted in the scientific works by M. Bohdanovych, N. Lystopad, N. Salan, S. Skvortsova, O. Onoprienko,

and others. In the context of using game technologies, S. Skvortsova (2018) notes that for the development of cognitive processes and the correction of certain traits in the digital generation of children, such as decreased attention, superficial thinking, worsened analytical-synthetic thinking, impaired analysis of phenomena, loss of ability to perceive complex texts, etc., within the system of math lesson tasks, it is necessary to include exercises that develop attention, tasks with logical complexity, and non-standard formulated tasks" (p. 34).

N. Lystopad (2020), in her works, reveals the specific features and possibilities of using game technologies at various stages of the math lesson and in the learning process outlined in the Standard Educational Programs of the mathematical field. Particularly, the scholar presents didactic games that contribute to the development of skills in younger students to work with data and apply knowledge in everyday life.

Despite the high interest among scientists and practicing teachers in the game technologies usage in the educational process, there has not been enough attention devoted to the substantive content, forms of implementation considering modern educational trends in organizing game activities, and consequently, determining the ergonomic conditions for the effectiveness of using didactic games in the process of teaching the mathematical field in primary school.

The aim of this article is to consider the range of target orientations of game technologies in teaching mathematics to primary school students, delineate the features of ergonomic requirements for game activities in the modern educational environment of primary school, and characterize the pedagogical conditions for the effectiveness of using didactic games in teaching the mathematical field.

Presentation of the main material. The aim of teaching mathematics is the multifaceted development of a child's personality and their worldview through mathematical activities, the formation of mathematical and other key competencies necessary for life and further education (*Навчальні програми для 1-4 класів,* 2022). Mathematics offers unique opportunities to achieve this goal and accomplish all objectives outlined in the Standard Educational Programs. Its study contributes to the development of attention, memory, speech, imagination, and fosters perseverance and the creative potential of the individual. For a student, mathematics starts not with numbers but with riddles and problems. It is through overcoming difficulties in solving various tasks that a young student develops the ability to understand

and evaluate mathematical facts and patterns, learns to make informed choices, and models processes and situations to solve different problems.

Children's memory works in such a way that they only assimilate what interests, surprises, or delights them. Simultaneously, for the development of mathematical thinking, it is necessary for them to feel wonder and a desire for knowledge. Game-based teaching technologies, relying on pedagogical guidance through play activities, are aimed at meeting the current needs of primary school students and realizing their individual potential through the usage of a system of pedagogical methods specific to the goals of a particular didactic game.

It is worth noting that didactic game is a form of organizing teaching, education, and personality development conducted by the teacher through purposefully organized student activities based on a specially designed gaming scenario, relying on the maximum self-organization of students in modeling the experience of the surrounding reality (Салань, 2016). Through playing, children develop habits of concentration, independent thinking, attention, and an interest in mathematics. Engrossed in the game, younger students do not notice they are learning. They explore and memorize new information, enrich their imagination and concepts, develop skills and abilities, orient themselves in unfamiliar situations, and enhance their creativity. Even the most passive children eagerly engage in the game, exerting effort not to let their team down.

In a math class, the teacher acts as the moderator of a didactic game, guiding and overseeing its structural components: the didactic objective, the gaming concept, rules of the didactic game, the gameplay itself, and the summary of the game's outcomes (*Навчальні програми для 1-4 класів,* 2022, p. 10).

Scientific and methodological literature suggests several didactic conditions for the successful usage of didactic games, especially in teaching primary school students in the mathematical field.

For instance, O. Savchenko (2012) identifies the didactic conditions for the effectiveness of using didactic games as the organic integration into the learning process, engaging names, the presence of truly playful elements such as beginnings and rhyming, mandatory adherence to the rules, the use of counters, and the emotional attitude of the teacher toward game actions (p. 309).

It is worth noting that adherence to these established didactic conditions is imperative when employing didactic games in the teaching

of mathematics to younger students. However, modern educational trends, including intensified learning, rethinking the possibilities of integration in new learning conditions, the immaturity and mobility of the psychophysiological system of the digital generation of children, active implementation of new computer educational technologies, teaching children with special educational needs in inclusive classes, and the introduction of distance learning, demand a review of established approaches to organizing game activities in math lessons. This requires adherence to specific pedagogical conditions for the effective usage of didactic games.

Some specific features of game activities in the modern educational environment of primary school should be characterize

Firstly, an essential characteristic of modern methodological systems that ensure goal achievement and mandatory learning outcomes in the mathematical field is the consideration of the peculiarities of contemporary students – representatives of the digital generation (Скворцова, & Онопрієнко, 2020, p. 6). Therefore, the professional practice of a modern primary school teacher utilizing gaming technologies in math lessons should rely on an optimal game structure, abandoning cumbersome game rules, meticulous selection of didactic games to activate students' perceptions, and maximal realization of motivational and developmental functions of didactic play. As noted by S.Skvortsova (2020), referring to psychologists' research, "consideration of the desire of the digital generation children to always be winners, their inability to delay gratification, and unwillingness to perform training exercises should be incorporated into the system of educational tasks, ensuring students' success in mathematical activities" (p. 12). Considering that contemporary children, on the one hand, are inundated with information and, on the other hand, constantly seek new information, game activities must evoke a sense of joy in learning. Planning the usage of any didactic games in math lessons should be based on understanding the cognitive peculiarities of contemporary children and addressing specific shortcomings.

Secondly, to foster the mathematical competence of primary school students, they need to acquire subject-specific and interdisciplinary knowledge and develop the experience of using this knowledge and methods to solve educational and real-life problems. Since mathematical competence is an integrated formation, its development requires various content and cognitive learning approaches

(*Про затвердження Державного стандарту…,* 2018). Consequently, didactic games should create conditions for the formation of a new way of thinking that goes beyond mathematics. Therefore, it is expedient to use narratives and information from other educational fields in their content. By solving interdisciplinary cognitive tasks during games, students' activity is directed towards exploring unknown connections or forming new concepts based on establishing specific interdisciplinary links. Through such playful activities, students receive scientific knowledge in an accessible and engaging form, acquire generalized cognitive strategies that not only enhance their cognitive abilities and academic achievements but also reduce the time needed for learning. This position becomes particularly relevant in the context of distance learning for primary school students.

Thirdly, the success of any human activity, as indicated by ergonomic studies, depends on its functional state, which is an integrated complex of personal characteristics, abilities, and qualities that directly or indirectly affect the execution of their tasks. The functional state is reflected in subjective experiences, fundamental mental processes, physiological characteristics, and manifests through behavior. An optimal functional state that aligns teaching tools and conditions with students' functional abilities is termed functional comfort (Карапузова, Зімниця, & Помогайбо, 2012). Therefore, the effectiveness of teaching using gaming technologies depends on the functional comfort of all participants in the learning process. Specifically, it is crucial for teachers to dedicate maximum attention and goodwill to students, ensuring that their remarks do not hinder a student's activity and initiative. Special attention should be given to excitable and vulnerable students or those with special educational needs. Nobody should be forced to join a game, and no child should face criticism for providing an incorrect answer during participation in such activities. Ergonomic requirements also the usage of didactic games utilizing computer technologies.

In characterizing ergonomic design requirements for educational gaming environments, it is notable that this includes the structuring of classroom space (designating educational centers, variations in student seating arrangements, timing of gaming activities, their pace and rhythm), and specific demands of didactic ergonomics (these requirements are based on the scientific principles of didactic design and the ergo-design concept of educational space).

Various forms of gaming activities in math lessons (project-based, team-based, group-based) require constant changes in location (working in pairs, groups of 3-4, etc.). Depending on the predominant type of activity, different ergonomic design variants for placing participants in the educational process are used (clusters, circles, semicircles, amphitheaters, in a "P" formation around the perimeter). Visual, auditory, and communicative comfort among students and towards the teacher, visibility of the classroom board, screen, or demonstration materials should be primarily considered.

Ergonomic requirements in this set of conditions extend to ensuring a rational sequence in task execution, methods of delivering and dosing educational influences (intellectual, physical, visual, tactile), the pace and monotony of educational process organization, optimal distribution of workload among students, adherence to work and rest regimes, etc., all of which prevent intellectual and nervous-emotional tension in schoolchildren. Temporal comfort in the educational process is crucial, dependent on the socio-type of the personality, temperament, and thinking style (auditory, visual, kinesthetic type) of the students.

In the context of our research, the requirements of didactic ergonomics involve planning didactic and material-technical objects of the educational environment that correspond to functional, aesthetic, and technological demands. For instance, the application and design of various types of educational resources should not only be pedagogically justified but also align with general and specific pedagogical-ergonomic requirements for teaching aids (screen-based, printed, natural objects, models, devices, etc.) (Карапузова, Зімниця, & Помогайбо, 2012).

According to the outlined features of organizing the learning process, we have defined the pedagogical conditions for the effectiveness of using didactic games in the teaching of mathematical education: considering the cognitive characteristics of digital generation students in the content of the structural components of didactic games; utilizing interdisciplinary connections to direct didactic games towards students' mastery of generalized cognitive activities; creating an ergonomic educational gaming environment to ensure the functional comfort of younger students during gaming activities.

Conclusions. Therefore, practice demonstrates that gaming technologies have wide-ranging potential to fulfill the goals and objectives of the mathematical content line in primary school. They are

meant to assist teachers in activating and intensifying students' learning activities, fostering a conducive psychological climate during mathematics classes, maintaining the interest of primary school students in learning, and developing their independence, creativity, responsibility, and purposefulness. Implementing ergodesign requirements for the educational gaming environment contributes to creating psychophysiological comfort for students, avoiding overload and fatigue, thereby enhancing their efficiency and preserving their health.

Prospects for further research. Given the significant changes in the educational environment, there is an urgent need for primary school teachers to modernize both the entire structure of didactic games and the ergonomic gaming environment and forms of active interaction among game participants to maximize the realization of its motivational and developmental functions.

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ІГРОВІ ТЕХНОЛОГІЇ У ПРОЦЕСІ НАВЧАННЯ МАТЕМАТИКИ УЧНІВ ПОЧАТКОВИХ КЛАСІВ: ЕРГОНОМІЧНИЙ ВИМІР

У статті висвітлено окремі теоретичні аспекти використання ігрових технологій у початковій школі. Визначено доцільність і розглянуто спектр цільових орієнтацій ігрових технологій у процесі навчання математики молодших школярів. Дидактична гра в процесі навчання математики є важливим засобом активізації навчально-пізнавальної діяльності учнів, розвитку логічного мислення та математичного мовлення. У молодших школярів формується звичка зосереджуватися, самостійно мислити, вміння розпізнавати і моделювати процеси й ситуації з повсякденного життя, які можна розв'язати з допомогою математичних методів. Охарактеризовано особливості ігрової діяльності в сучасному освітньому середовищі початкової школи. Незрілість і рухливість психофізіологічної системи дитини молодшого шкільного віку, з одного боку, інтенсифікація навчання, активне впровадження нових освітніх технологій, навчання дітей з особливими освітніми потребами в інклюзивних класах, з іншого боку, вимагають перегляду усталених підходів до організації ігрової діяльності на уроках математики. Окреслено ергономічні педагогічні умови ефективного використання дидактичних ігор у процесі вивчення математичної освітньої галузі: врахування когнітивних особливостей навчання учнів цифрового покоління у змісті структурних компонентів дидактичних ігор; використання міжпредметних зв'язків із метою орієнтації дидактичних ігор на оволодіння учнями узагальненими прийомами пізнавальної діяльності; забезпечення функціонального комфорту дітей у процесі ігрової діяльності.

Ключові слова: *початкова школа; ігрові технології навчання; дидактична гра; математична освітня галузь; педагогічні умови; ефективність; навчальний процес.*

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