# INTEGRATION OF GAME-BASED TECHNOLOGIES INTO THE TRAINING OF FUTURE PRESCHOOL TEACHERS FOR DEVELOPING LOGICAL AND MATHEMATICAL CONCEPTS IN PRESCHOOL CHILDREN

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DOI: https://doi.org/10.30525/978-9934-26-715-4-32

**Abstract.** The paper addresses the integration of game-based technologies into the professional training of future preschool teachers for developing logical and mathematical concepts in preschool children. The relevance of this problem stems from the need to overcome the gap between students' theoretical knowledge of logical and mathematical development and their readiness to design meaningful play in which quantitative, spatial, temporal, geometric, and logical relations become the subject of independent action, verbal explanation, verification, and transfer to new situations. The content, structure, pedagogical conditions, and phased model of this integration are analysed. *The purpose* of the paper is to provide a theoretical rationale for a comprehensive training model, identify the components of professional readiness, and develop practical tools for analysing, designing, testing, and evaluating mathematically meaningful games. *Methodology.* The study combines systemic, competence-based, activity-based, learner-centred, and technological approaches. Its methods include analysis of regulatory documents and contemporary Ukrainian and international research; comparison of play-based learning, guided play, gamification, and digital educational games; conceptual clarification; systematisation of logical and mathematical content and game mechanics; pedagogical modelling; development of readiness criteria and indicators; and synthesis of learning,

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laboratory, and practical activities. *Results.* Game-based technology is defined as a designed and reproducible system of objectives, mathematical content, rules, materials, roles, pedagogical support, differentiation, and assessment. Five components of a future preschool teacher's readiness are identified: motivational and value-based, cognitive and content-based, operational and methodological, design and technological, and reflective and evaluative. The model comprises five consecutive stages: diagnostic and motivational, content and analytical, design and technological, practical and testing, and reflective and evaluative. The relevant pedagogical conditions include interdisciplinary integration, alternation of students' professional roles, iterative prototyping, a balance between guided play and children's agency, practical testing, inclusive design, safe use of digital tools, and criteria-based reflective assessment. *Practical implications.* The practical outputs include a matrix linking game-based technologies with logical and mathematical tasks, an algorithm for preparing a game design brief, a system of learning tasks, and criteria for determining levels of readiness. Game effectiveness should be assessed through observable actions of children - their counting methods, explanations of choices, changes in strategy, use of mathematical vocabulary, and transfer of a method to a new situation – rather than through visual appeal or general impressions. This approach connects the future preschool teacher's professional reflection with evidence of children's cognitive development. *Value/originality.* Effective integration requires alignment among mathematical accuracy, genuine play interaction, and pedagogically appropriate support. Professional training should therefore be organised as a continuous cycle from participation and analysis to design, testing, evidence-based reflection, and redesign.

## INTRODUCTION

The relevance of the problem is not accidental, since contemporary preschool education expects teachers not to transmit a fixed set of mathematical facts but to create conditions in which children actively explore quantitative, spatial, temporal, geometric, and logical relations. At preschool age, these relations are learned mainly through action with objects, shared play, verbal explanation, experimentation, and practical problem-solving. The quality of logical and mathematical development therefore depends not only on whether a preschool teacher knows the content of elementary

mathematics, but also on the ability to turn this content into an accessible, emotionally engaging, and intellectually rich activity for the child.

The regulatory basis of the problem is outlined in documents governing different levels of education. The Basic Component of Preschool Education identifies sensory and cognitive, logical and mathematical, and research competences as important outcomes of preschool education. These competences involve analysing the properties of objects, establishing relations, counting, measuring, orientating in space and time, reasoning, and applying acquired experience in everyday situations [1]. The Higher Education Standard for Specialty 012 Preschool Education requires graduates to be able to develop children's concepts of number, shape, size, space, and time, organise cognitive activity, and select methods and technologies according to children's age and individual characteristics [2]. The Professional Standard for Preschool Teachers strengthens the requirements for designing the educational process, creating a developmental environment, building pedagogical partnerships, and assessing children's achievements [3].

In this context, play cannot remain merely a way to make educational activities more emotionally appealing or a reward offered after a learning task. It should organise mathematical cognition so that children work with quantities, shapes, sequences, and spatial relations in pursuit of a play goal. However, the presence of a story, character, points, or a colourful digital interface does not by itself guarantee a learning effect. Play becomes mathematically productive only when its rules require the target mental action, the task lies within the child's zone of proximal development, the teacher supports the child's reasoning, and the outcome can be observed and discussed.

At the same time, the training of future preschool teachers continues to reveal a contradiction between the theoretical study of methods for developing elementary mathematical concepts and the fragmented mastery of game design. Students may be able to name types of didactic games yet experience difficulty defining a mathematical objective, constructing rules, selecting an appropriate level of complexity, organising pedagogical support, assessing children's strategies, and transferring a game to different educational situations. Ukrainian studies likewise indicate the need to strengthen the technological and practical components of

preparing future preschool teachers for children's logical and mathematical development [4-6].

It is therefore important to justify a model for integrating game-based technologies into professional training that combines mathematical accuracy, a psychological and pedagogical understanding of play, design technology, practical testing, and reflection. The issue is not the addition of a separate topic entitled "Games for Mathematics", but the organisation of an integrated learning process in which students successively act as players, analysts, designers, facilitators, and researchers of children's play.

Research on play in preschool education is developing around several interrelated questions: the relationship between free play and pedagogically supported play; the defining features of learning through play; the adult's role; the design of the play environment; and the relationship between engagement, autonomy, and educational outcomes. A systematic review of early childhood teachers' views showed that teachers generally recognise the value of play, but interpret the limits of adult guidance differently and often experience tension between curriculum requirements and support for children's initiative [7]. Preparing students to select a conscious pedagogical position is therefore a distinct task of professional education.

International evidence provides further detail. A systematic review and meta-analysis of game-based learning in early childhood found positive effects on cognitive, social, emotional, and motivational outcomes, while also emphasising that effectiveness depends on design, duration, context, and the adult's role [8]. A meta-analysis of guided play showed that combining children's activity with purposeful adult prompts can be particularly productive for certain learning outcomes, including early mathematics. However, guided play is not a universal technology and requires clearly defined goals and high-quality pedagogical support [9].

A separate area of research concerns mathematical board and digital games. A systematic review of mathematics games used in preschool institutions and families indicates that they can support early numerical concepts, although outcomes depend on the structure of the game board, frequency of repetition, nature of interaction, representation of numbers, and adult preparedness [10]. Experimental studies of linear number board games have shown that short series of play can improve children's understanding of numerical magnitude, order, and the relationship between symbols

and quantities [11]. Subsequent observations have also demonstrated the potential of using game tools in preschool small-group interaction [12].

These findings are supplemented by a randomised trial of an integrated playful learning curriculum, which demonstrated the promise of including playful mathematical activities systematically rather than episodically in preschool children's daily lives [13]. Digital tools also create opportunities not only for cognitive activity but for game-based assessment of mathematical competences. The study of the House of Numbers environment showed that game-based assessment can combine appeal for preschool children with psychometrically acceptable measurement of selected mathematical skills [14].

For teacher education, studies of game design rather than the consumption of ready-made games are particularly valuable. Research on future early childhood specialists designing digital educational games indicates that this activity can strengthen confidence in their capacity to create game products. However, participation in a design project does not automatically change every professional attitude and requires pedagogically organised reflection [15]. Current studies of digital mathematics learning also stress that technological appeal must be combined with age appropriateness, high-quality feedback, verbal interaction, and teacher involvement [16].

The content of early mathematics should not be reduced to counting. Spatial construction and model assembly are related to early mathematical skills, which supports the use of puzzles, blocks, tangrams, construction games, and spatial tasks [17]. Contemporary approaches to learning through play also emphasise cooperation between educational institutions and families. Mathematical games can be transferred to everyday situations if adults encourage questions, comparison, prediction, and explanation without turning play into formal home practice [18]. Recent research on preschool teachers' pedagogical knowledge points to the need for purposeful development of their understanding of early mathematics, observation methods, and forms of pedagogical support [19].

In Ukrainian research, the preparation of future preschool teachers for children's logical and mathematical development is viewed as an integration of professional knowledge, methodological skills, and practical experience. L. Berezovska emphasises the need to update technological tools and involve students in active modelling of pedagogical situations [4]. V. Khodunova

substantiates the innovative potential of game-based technologies in professional training and their influence on students' activity, motivation, creativity, and professional interaction [5]. D. Trush and O. Vilkhova systematise contemporary game-based means for developing preschool children's logical and mathematical competence and underline the value of combining traditional and digital formats [6].

Despite the large body of research, the end-to-end integration of game-based technologies into future preschool teachers' training remains insufficiently systematised. Such integration should extend from mastering mathematical content and analysing game mechanics to creating an original product, microteaching, testing with children, and evidence-based evaluation of outcomes. The conceptual framework, structure of professional readiness, stages of training, pedagogical conditions, and quality criteria for students' game designs require further alignment.

The purpose of the paper is to provide a theoretical rationale for the content, structure, pedagogical conditions, and phased model for integrating game-based technologies into the training of future preschool teachers for developing logical and mathematical concepts in preschool children.

The methods included analysis of regulatory documents and research sources; comparison of approaches to learning through play, guided play, gamification, and digital games; conceptual and terminological clarification; systematisation of logical and mathematical content and game mechanics; pedagogical modelling; development of criteria and diagnostic indicators; and synthesis of possible forms of learning, laboratory, and practical activity for higher education students.

## 1. Conceptual Foundations for Integrating Game-Based Technologies

In pedagogical discourse, the terms "play", "game-based method", "game-based technology", "learning through play", "guided play", "gamification", and "digital educational game" are often used interchangeably. Such conceptual ambiguity is problematic in the professional training of future preschool teachers because each format has a different design logic, degree of child autonomy, adult role, and method of assessment.

Free play is initiated and largely organised by children; its content, rules, and duration may change according to the participants' ideas. It has intrinsic developmental value, although a specific mathematical outcome

is not always directly predictable. Learning through play is a broader concept and includes situations in which play or playful activity becomes an environment for achieving defined educational goals. Guided play preserves children's activity, choice, and positive emotional engagement, while the teacher purposefully designs the environment, provides materials, asks open questions, models a strategy, or offers the minimum support required [9; 20].

Gamification refers to the use of separate game elements in a non-game process, such as points, levels, badges, rankings, missions, and progress bars. It can support motivation, but it does not necessarily create full play activity or guarantee an understanding of mathematical relations. A digital educational game is a software-based environment with rules, feedback, and a learning objective. Its value is determined not by the screen format itself, but by the quality of its mathematical model, ease of control, absence of unnecessary stimuli, opportunities to verbalise actions, and connection with hands-on activity [14; 16].

Based on these approaches, game-based technology in the training of future preschool teachers is defined as a designed and reproducible system of objectives, content, game mechanics, rules, materials, participant roles, pedagogical support, differentiation, and assessment. This system enables students to gain experience in designing, facilitating, and analysing mathematically meaningful play. Unlike a separate game-based technique, a technology involves a complete cycle: diagnosing needs, designing, implementing, observing children's actions, reflecting, and improving.

From this perspective, integration means the end-to-end inclusion of game-based technologies in both the content and methods of professional training. Students do not merely read about play. They play mathematical games, deconstruct their mechanics, relate them to age-related patterns, modify parameters, create a prototype, test it in microteaching, try it in a preschool institution, and analyse children's strategies. In this way, learning through play, learning about play, and learning to design play are combined.

The next step is to clarify the content embedded in game design. Work on a game should begin not with a story or a set of materials, but with a precise definition of its mathematical component. The concept of logical and mathematical understanding includes initial ways of perceiving,

distinguishing, generalising, and using quantitative, spatial, temporal, geometric, and logical relations. Its development is a transition from acting with concrete objects to visual modelling, verbal explanation, and the application of a method in a new situation.

The quantitative and numerical strand includes establishing one-to-one correspondence, counting, understanding conservation of number, relating a number to a set, ordinal relations, number composition, and simple operations of combining and removing. The measurement strand covers comparison by length, mass, capacity, area, and duration, the use of non-standard units, and understanding that a measurement result depends on the size of the unit. The geometric and spatial strand involves recognising and constructing shapes, analysing their properties, orientating in relation to oneself and other objects, and reading diagrams and routes. Temporal concepts are formed through the sequence of events, rhythm, duration, parts of the day, days of the week, and seasonal cycles.

The logical component includes classification by one or more attributes, seriation, pattern recognition, negation, set inclusion, causal relations, identification of a missing element, combination, and problem-solving. A game should not reduce logic to guessing the correct card. Children should explain the basis for grouping, predict the next element, compare strategies, identify an error, change a rule, or create their own sequence.

These content strands should be embodied in a target mathematical action. In a linear board game, for example, moving a number of spaces corresponding to a die roll supports the relationship among a number, a quantity of moves, and spatial distance [10-12]. In a "shop" game, the target action may involve assembling a set with a specified number of items, comparing prices, or finding several ways to calculate. In a construction game, it may involve reproducing a model from a diagram, transforming a structure, identifying symmetry, or describing spatial location. In a pattern game, it may consist of continuing, correcting, or creating a sequence and justifying the rule.

Students must distinguish visible activity from mathematical thinking. Moving cards, tapping a screen quickly, or competing for tokens may create an impression of active participation without requiring analysis of relations. A game design brief should therefore specify the action performed by the child, the mathematical relation revealed through that action, how the

teacher will recognise the child's strategy, which question will prompt an explanation, and how the task can be made more complex without undermining the idea of the game.

On this basis, future preschool teachers' readiness to use game-based technologies for logical and mathematical development is understood as an integrated professional quality. It combines a positive attitude towards children's play, understanding of mathematical content, command of methods of pedagogical support, ability to design and adapt game systems, and reflective evaluation of their influence. The structure of readiness comprises five interrelated components presented in Table 1.

Table 1

**Components of future preschool teachers' readiness to integrate game-based technologies**

| Component | Content | Expected manifestations |
|---|---|---|
| Motivational and value-based | Recognition of play as a leading form of children's cognition; respect for initiative and the right to choose and make mistakes; interest in mathematical development. | Supports engagement without pressure; explains the pedagogical value of play; avoids superficial entertainment. |
| Cognitive and content-based | Knowledge of early mathematics, age-related patterns, types of play, and principles of guided play, gamification, and digital learning. | Identifies the precise mathematical action; detects content errors; relates tasks to age and prior experience. |
| Operational and methodological | Ability to organise play, ask questions, model strategies, provide prompts, and observe and document children's actions. | Balances freedom and support; uses mathematical language; responds to different children's strategies. |
| Design and technological | Design of objectives, rules, mechanics, materials, levels of complexity, inclusive adaptations, and digital components. | Creates a coherent game design brief; prototypes, tests, and modifies; ensures that the technology can be reproduced. |
| Reflective and evaluative | Self-analysis and evaluation of mathematical accuracy, game quality, children's achievements, ethics, and safety. | Uses observations and children's statements; makes justified changes to a game; acknowledges limitations of the results. |

*Source: compiled by the author*

Table 1 shows that the motivational and value-based component determines a student's position towards play: whether it is understood as an independent cultural form and a space for children's agency or merely as a way of compelling children to practise. The cognitive and content-based component ensures mathematical accuracy. Without an understanding of the cardinal and ordinal meanings of number, the transitivity of relations, principles of classification, or spatial transformation, a future preschool teacher may create an appealing but methodologically flawed game.

The operational and methodological component becomes visible in direct interaction. A teacher must recognise a child's strategy in time, avoid replacing the child's action with an adult explanation, ask a productive question, provide graduated support, and foster mathematical language. The design and technological component makes an original idea transparent, systematic, and reproducible by other specialists. The reflective and evaluative component shifts attention from subjective impressions such as "liked it/did not like it" to an objective analysis of developmental effects and children's actual achievements.

**2. Game Formats and the Phased Model of Professional Training**

The identified structure of readiness cannot be developed through one "universal" type of game. It requires a system of formats, each with its own didactic possibilities and limitations. Table 2 relates game-based technologies to target mathematical content, children's activity, and the teacher's role.

As Table 2 indicates, the proposed structure does not establish a rigid "one game – one skill" correspondence. Role play may include counting, measurement, and spatial planning; a board game may involve logical strategy and verbal argumentation; and an active game may include route coding and work with sequences, thereby fostering algorithmic thinking through kinaesthetic experience. At the same time, overloading one game with many objectives makes outcomes difficult to observe. During training, students should learn to identify one leading mathematical action and one or two supporting actions.

Table 2

**Relationship between game-based technologies and logical and mathematical tasks**

| Game-based technology | Mathematical potential | Example of a child's action | Pedagogical support |
|---|---|---|---|
| Object-manipulation games | Correspondence, quantity, size, classification, and seriation. | Pairs objects; arranges items by length; changes the basis for grouping. | Asks the child to explain an attribute; offers a counterexample; changes one condition. |
| Board, card, and number games | Counting, order, numerical magnitude, number composition, and probabilistic concepts. | Moves along a number path; selects a card; predicts who is closer to the finish. | Encourages children to verbalise numbers and strategies; does not reduce the game to speed. |
| Mathematical role-play situations | Contextual counting, measurement, comparison, planning, and exchange. | Completes an order; measures material; plans a delivery route. | Creates a problem situation; introduces mathematical vocabulary through the role. |
| Construction games | Shape, space, symmetry, part-whole relations, diagrams, and combination. | Reproduces a model; completes a symmetrical part; describes a location. | Asks about the plan; offers another viewpoint; records the construction method. |
| Active mathematical games | Spatial orientation, sequence, rhythm, counting, and distance measurement. | Follows a coded route; forms groups; repeats a rhythmic pattern. | Ensures safety; changes a rule; involves children in creating instructions. |
| Logic quests and escape elements | Patterns, deduction, coding, combination, and problem-solving. | Finds a missing element; reads a symbolic clue; tests a hypothesis. | Grades the prompts; supports team explanations; avoids excessive complexity. |
| Digital educational games | Adaptive practice, modelling, immediate feedback, and game-based assessment. | Compares sets; transforms a shape; solves a series of related tasks. | Checks content quality; limits screen time; combines digital play with hands-on action. |
| Games created by children | Metacognition, rule modelling, combination, and mathematical language. | Invents a rule, board, and way to win; tests a peer's game. | Helps make the rule clear; asks about fairness and complexity. |

*Source: compiled by the author*

Games created by children occupy a special place. To invent a rule, a child must understand which actions are permitted, how the outcome is determined, whether the game is fair, and what to do in a disputed situation. For older preschool children, this can become a form of metamathematical reflection: they not only solve a task but model a system of relations. A future preschool teacher should support such authorship without turning the child's idea into an adult-designed didactic product.

Building on the identified components and game formats, the proposed model can be implemented within courses such as Theory and Methods of Developing Elementary Mathematical Concepts, Preschool Pedagogy, and Innovative Technologies in Preschool Education, as well as during teaching practice or within an interdisciplinary module. Its logic is based on a gradual transition from students' own experience of play to independent design, testing, and assessment. Table 3 summarises the sequence of model implementation.

At the diagnostic and motivational stage, it is important to identify not only knowledge of terms but also implicit beliefs. Some students equate mathematics learning with cards and correct answers, and play with an absence of goals and rules. Others tend to overestimate digital products or, conversely, reject them without analysis. Reflective discussion of personal play experience helps students determine how rules regulate behaviour, which emotions arise in situations of failure, how competition changes interaction, and why the same game affects participants in the educational process differently.

The content and analytical stage involves the "deconstruction" of a game. Students identify its mathematical core, play goal, rules, cycle of action and feedback, degree of chance and strategy, ways of ending, role of language, possible errors, and methods of observation. It is useful to compare two games addressing the same content: for example, a mechanical number-card matching activity and a linear board game in which a number corresponds to an actual distance on the board. Such analysis develops the ability to evaluate cognitive structure rather than external appearance.

On the basis of this analysis, the design and technological stage is organised as a design studio. A team receives a pedagogical challenge, a description of the group, and resource constraints. After defining the purpose and objectives, students create a low-tech prototype from paper, counters,

blocks, or natural materials. They conduct a rapid test with peers and record unclear rules, dead turns, excessive randomness, unjustified waiting time, and opportunities for one participant to dominate. A story, aesthetic design, or digital component should be added only after the mathematical and play logic has been verified.

Table 3

**Stages of the model for integrating game-based technologies**

| Stage | Main tasks | Forms of work | Outcome |
|---|---|---|---|
| Diagnostic and motivational | Identify ideas about play and mathematics, experience, stereotypes, digital habits, and readiness to cooperate. | Self-assessment; participation in a game; discussion; analysis of controversial cases. | Personal goal; awareness of the difference between play and an "exercise with a story". |
| Content and analytical | Deepen knowledge of early mathematics; learn to deconstruct mechanics, rules, the adult's role, and evidence of learning. | Game laboratory; video analysis; expert review of ready-made games; mathematical audit. | Analytical game map; ability to identify strengths, risks, and errors. |
| Design and technological | Create a prototype with a clear objective, mechanics, differentiation, inclusive adaptations, and observation tools. | Design studio; team sprint; consultation; peer review; prototype testing. | Design brief and prototype of an original game; options for simplification and increased complexity. |
| Practical and testing | Practise facilitation, conduct microteaching and testing with children, and collect data on strategies and engagement. | Role simulation; microteaching; teaching practice; observation. | Implementation experience; observation records; identified difficulties and children's needs. |
| Reflective and evaluative | Compare the design with actual play; evaluate mathematical accuracy, children's agency, safety, and transfer. | Reflective report; video analysis; product defence; portfolio; peer assessment. | Improved game; reasoned professional position; individual development pathway. |

*Source: compiled by the author*

The practical and testing stage logically continues the design process by combining microteaching with teaching practice. During microteaching, some students assume the roles of children with different educational needs: an impulsive child, a silent observer, a child with advanced knowledge, a participant who does not understand the rules, or a child who is sensitive to losing. This makes it possible to test the instructions, pace, prompts, and means of inclusion before meeting an actual group. During testing, students collect observation data rather than "children's scores": statements, counting methods, errors, requests for help, changes in strategy, and the duration of independent engagement.

While completing the preceding stages, the reflective and evaluative stage also initiates a new iteration. Students compare the expected and actual course of the game and determine whether the mathematical action was necessary for success; whether children had choices; which prompts supported thinking and which replaced it; who remained passive; whether mathematical language emerged; and how the rules, materials, or complexity should be changed. The improved product, together with evidence of the changes, is included in a professional portfolio.

### 3. Pedagogical Conditions and Practical Implementation Tools

Implementation of the model requires a set of pedagogical conditions. The first condition is interdisciplinary integration of mathematical, psychological, pedagogical, methodological, and digital content. Designing a game requires simultaneous consideration of mathematical structure, age-related abilities, motivation, language support, group dynamics, inclusion, safety, and the properties of materials. If these issues are distributed across separate courses without a common task, students find it difficult to synthesise them into a real pedagogical solution. An interdisciplinary module or a joint project led by several lecturers enables work on one product from different professional perspectives.

The second condition is the systematic alternation of the roles of player, analyst, designer, facilitator, and researcher. A description of didactic games alone does not develop sensitivity to pace, tension, uncertainty, fairness of rules, and the experience of losing. Students' own participation should become an object of reflection: what encouraged the search for a strategy,

when interest disappeared, whether an error was informative, how feedback influenced the experience, and who controlled the process.

The third condition is the compulsory design of original games through several prototyping cycles. Copying ready-made material may be an initial stage, but it does not demonstrate a student's ability to connect an objective with mechanics. A design task should require justification of every element: why the board has a particular number of spaces, what role randomness plays, how a rule ensures comparison or seriation, why a child cannot win while avoiding the mathematical action, and how repeated use of the method is supported.

The fourth condition is the combination of guided play with support for children's agency. A future preschool teacher should learn not only to give instructions but also to create space for choice: children may select materials, strategies, roles, levels of complexity, or ways of recording a result, and may be invited to change the rules or create a continuation. Pedagogical guidance is expressed not through constant control but through a thoughtfully designed environment, precise questions, and timely minimal support [9; 20].

The fifth condition is practical testing and partnership with preschool education institutions. Adult peers cannot fully reproduce a child's way of understanding a rule, pace of action, or emotional response. A complete training cycle therefore requires observation of children under the supervision of a mentor teacher, ethical recording of data, discussion with the group teacher, and revision of the product. Testing must not turn children into "test material": the game should be safe, consistent with the educational programme, and any photography or video recording should follow established privacy rules.

The sixth condition is differentiation and inclusive design. Game-based technology should provide participation options for children with different working rates, language abilities, sensory characteristics, and levels of mathematical experience. Differentiation does not mean creating a "weak" and a "strong" game. Appropriate variables include the number of elements, mode of representation, scope of the rule, availability of prompts, partner format, response time, requirement for explanation, and openness of the task. Universal design of materials requires sufficient contrast, readable symbols,

tactile elements, the absence of small dangerous parts, and opportunities to participate without relying on speed.

The seventh condition is pedagogically and ethically responsible use of digital tools. Students should evaluate not a brand or the amount of animation, but content relevance, transparency of the rules, quality of feedback, presence of advertising, data collection, possibility of making an error without punishment, accessibility for shared interaction, and connection with hands-on play. A digital game is appropriate when it can model, vary, visualise, or adapt something that is difficult to achieve by other means, rather than merely replacing cards with a screen [14-16].

The eighth condition is criteria-based reflective assessment. The evaluation of a future specialist's product should consider at least three equally important dimensions: mathematical accuracy, quality of play, and pedagogical appropriateness. Additional dimensions include inclusion, safety, ethics, technological feasibility, and the evidence base of reflection. Such a system prevents a visually attractive but mathematically empty or excessively directive game from receiving a high score.

Within these conditions, students' practical work should be organised through a game design brief, a structured document that makes an idea transparent and suitable for expert review. Its preparation involves the following steps.

The first step is to describe the educational context: age group, approximate prior experience, number of participants, location, and duration. The second is to formulate the mathematical objective as an observable child action, for example, "compares two sets without recounting and explains how the larger quantity is identified", rather than "reinforce knowledge of quantity". The third is to define the play goal: what the player seeks to achieve within the story or system of rules. The educational and play goals should be connected but not identical.

The fourth step is to select the basic mechanics: movement across a board, matching pairs, construction, exchange, hidden information, cooperative completion of a mission, classification, route coding, or pattern creation. The fifth is to construct rules that make the mathematical action necessary. If a child can win by chance or by copying a neighbour without using the target relation, the game should be redesigned. The sixth is to select materials and forms of representation: real objects, images, symbols,

diagrams, numbers, or digital objects. The representation should be age-appropriate and gradually support a transition from concrete action to modelling.

The seventh step is to design pedagogical support. The brief records the initial instruction, open questions, possible children's strategies, common errors, levels of prompts, and ways of introducing mathematical terms. Prompts should progress from the least directive to the more specific: repeat the condition; ask the child to describe what is already known; direct attention to the material; demonstrate part of the action; and model the method only when necessary.

The eighth step is differentiation. Students prepare at least one simplified version, one more complex version, and one inclusive adaptation. The ninth step is an observation plan: which statements, gestures, counting methods, choices, or errors will indicate understanding, and how data will be recorded without interrupting play. The tenth step defines completion and transfer criteria: how the game ends, what is discussed afterwards, and in which new situation the child will be able to apply the method.

A game design brief should not turn play into a rigid script. Its function is to help future specialists anticipate pedagogical decisions while leaving room for children's initiative. After testing, a section entitled "Actual process and changes" is added to record specific observations and revisions rather than general impressions.

A set of learning tasks with progressively more complex professional actions logically follows the proposed algorithm. At the initial level, a student conducts a mathematical audit of a ready-made game: identifies the target action, finds points at which a child can act randomly, checks the accuracy of symbols and rules, and proposes questions that prompt explanation. Another task, "one objective, three mechanics", requires the creation of an object-manipulation, active, and board-game version for one mathematical skill and a comparison of their possibilities.

At the analytical level, a video case is appropriate. Students watch a short fragment of play, record only observable actions, separate them from interpretations, identify the teacher's position, and propose an alternative prompt. In the "redesign an unsuccessful game" task, students receive a product with typical weaknesses: too many rules, dominance of chance, unproductive competition, excessive waiting time, or decorative

mathematical content. They should change the fewest possible elements and explain how each change affects children's thinking.

At the design level, a team prepares a complete brief and game prototype, tests it with another group, collects structured feedback, and produces a second version. Limiting materials or the budget is useful because it redirects attention from decoration to mechanics and accessibility. A separate task may concern a digital product: students evaluate an application according to mathematical quality, age appropriateness, privacy, advertising, feedback, and opportunities for joint discussion.

At the practical level, a student conducts microteaching and later tests the game in a preschool group. The task is not to "deliver the game successfully according to plan", but to identify children's strategies and make justified decisions. For example, if a child repeatedly recounts objects when the objective is to compare sets through one-to-one correspondence, the teacher may suggest arranging the objects in pairs. If a child gives an answer quickly, the student asks for another method or invites the child to explain it to a partner.

The final product should be a professional portfolio containing an analytical map of a ready-made game, a design brief for an original game, photographs of materials without children's personal data, observation records, the first and improved versions of the rules, a reflective report, and a short scenario for transferring the game to a family context. Such a portfolio demonstrates both the final result and the process of professional reasoning.

## 4. Readiness Assessment and Implementation Risks

The following criteria are proposed for assessing future preschool teachers' readiness to foster preschool children's logical and mathematical development through game-based technologies: motivational and value-based, mathematical and content-based, methodological and facilitative, design and technological, and reflective and evidence-based. Each criterion is specified through indicators, allowing self-assessment, lecturer expert assessment, peer assessment, and analysis of activity products to be combined. Table 4 presents a general description of readiness levels according to these criteria.

Table 4

**Criteria and general characteristics of readiness levels**

| Criterion | Initial level | Functional level | Creative professional level |
|---|---|---|---|
| Motivational and value-based | Views play mainly as entertainment or a means of discipline; focuses on the correct answer. | Recognises the cognitive value of play; supports choice and the right to make mistakes in typical situations. | Consistently protects children's agency; explains the balance between freedom and pedagogical intent. |
| Mathematical and content-based | Formulates a general objective; allows inaccuracies; does not distinguish an action from its result. | Correctly identifies mathematical content and typical strategies within familiar topics. | Reveals hidden relations, predicts errors, and creates tasks for transfer and generalisation. |
| Methodological and facilitative | Dominates play, frequently suggests the answer, and uses closed questions. | Organises rules, asks open questions, and provides graduated support. | Changes position flexibly, supports dialogue among children, and turns error into a resource for inquiry. |
| Design and technological | Copies ready-made games; the story is weakly related to the objective; adaptations are absent. | Creates a workable game with aligned objectives, rules, and levels of complexity. | Designs a variable system, tests several versions, and integrates traditional and digital tools appropriately. |
| Reflective and evidence-based | Evaluates through the general impression that "children liked it"; does not record strategies. | Uses observation notes, relates them to the objective, and makes individual changes. | Collects different forms of evidence, critically analyses limitations, and justifies redesign and the next cycle. |

*Source: compiled by the author*

The initial level should not be equated with a lack of ability: it indicates a need for structured analysis, modelling, and support. The functional level means the ability to act effectively in typical professional situations using familiar models. The creative professional level is characterised by flexible transfer of principles, independent identification of problems, reasoned

redesign, and the ability to create new solutions without losing mathematical or pedagogical quality.

Assessment should therefore be conducted at different stages rather than as a single event. At the beginning of the course, self-assessment and analysis of a ready-made game are used. During the course, a prototype rubric, observation of microteaching, and peer assessment are appropriate. At the end, students defend their portfolios and compare the first and improved versions. Assessment should cover not only an error-free product but also the ability to identify a problem, accept feedback, and explain the changes made.

The practical implementation of the model also involves several risks. The first is the replacement of a mathematical objective with external game attributes. A character, story, competition, or reward may be attractive while concealing the same reproductive exercise. Future preschool teachers should therefore learn to ask a control question: what exactly in this rule makes the player compare, count, measure, classify, or reason?

The second risk is excessive reliance on external rewards and competition. Rankings, points, and speed can reduce a slower child's willingness to explain a strategy, encourage domination, and make errors feel threatening. Cooperative goals, personal progress, joint problem-solving, and the possibility of several valid strategies are often more productive for preschool children's logical and mathematical competence. Competition should be used only when emotional safety is maintained and humiliation is excluded.

The third risk is excessive adult guidance. The desire to secure the correct result may lead a teacher to ask leading questions with obvious answers, correct every step, and rush the child. The game then retains its external form but loses choice, uncertainty, and inquiry. Training should include practice in silent observation, waiting, neutral clarification, and graduated prompts.

The fourth risk concerns digital tools: excessive stimulation, passive tapping, advertising, collection of personal data, inaccessible purchases, mathematically inaccurate content, and individualisation at the expense of live interaction. Students should be able to read a privacy policy, test a product in child mode, identify hidden reward mechanisms, and plan a short post-game conversation or hands-on continuation. The digital format

should not displace manipulation of real objects, movement, and shared language.

The fifth risk is formal assessment. High engagement is not identical to logical and mathematical development, and a correct answer does not always indicate understanding. A child may have guessed, copied another participant, or memorised the position of a card. Students should therefore collect different evidence: ask for an explanation, request another method, change the materials, or invite transfer of the task to a new story. At the same time, a single observation does not support broad conclusions about competence.

The sixth risk is a mismatch between the game and its cultural and family context. Stories, images, rules of exchange, competition, or roles may have different meanings for different children. Partnership with families and the use of familiar everyday situations help make mathematical content relevant. A home version of a game should be simple, inexpensive, voluntary, and should not require parents to have specialist pedagogical training [18].

The scientific novelty of the paper lies in clarifying the integration of game-based technologies as an end-to-end cycle of professional learning in which a future preschool teacher successively masters the roles of player, analyst, designer, facilitator, and researcher; in defining a five-component structure of readiness; and in developing a phased model and criteria for its assessment. Unlike approaches that treat play as a set of methodological techniques, the proposed model focuses on students' design activity and evidence-based reflection.

The practical significance of the results lies in the possibility of using the structure of game-based technologies, the game design brief, the set of tasks, and the assessment rubric in courses on methods of developing elementary mathematical concepts, practical classes, and teaching practice.

Accordingly, the expected professional outcome of the model is not the accumulation of a large number of ready-made games, but the ability to select, adapt, and create game-based solutions critically. A preschool teacher trained in this way understands the mathematical relation embedded in an action, recognises a child's strategy, ensures emotionally safe interaction, uses digital tools with reasoned judgement, and improves the game on the basis of observation data.

## CONCLUSIONS

The analysis demonstrates that the integration of game-based technologies into the training of future preschool teachers is not a local methodological addition. It is a way of restructuring professional learning around active, design-based, and reflective activity. Its effectiveness depends on the precise combination of three dimensions: mathematical content, genuine play interaction, and pedagogically appropriate support. The loss of any dimension produces either mathematically empty entertainment, a reproductive exercise with a decorative story, or an over-directed activity without children's agency.

Future preschool teachers' readiness to use game-based technologies includes motivational and value-based, cognitive and content-based, operational and methodological, design and technological, and reflective and evaluative components. It should be developed in stages: from diagnosing beliefs and personal play experience, through analysis of mathematical content and game mechanics and the creation and testing of a prototype, to practical implementation, collection of evidence, and redesign. The pedagogical conditions for implementation include interdisciplinary integration; alternation of students' professional roles; iterative design; a balance between guided play and children's initiative; partnership with preschool education institutions; differentiation and inclusive design; safe and justified use of digital tools; and criteria-based reflective assessment. The practical tools – a game matrix, project design brief, learning tasks, and assessment criteria – can provide the basis for a relevant module in the professional training of future preschool education specialists.

Further research should include experimental verification of the model, development of valid diagnostic tools, comparison of different microteaching formats, investigation of students' transfer of acquired skills to teaching practice, and examination of longer-term effects on the quality of mathematical interaction with children. Inclusive game-based technologies, the use of artificial intelligence to develop adaptive tasks, protection of children's data, and forms of partnership with families that do not turn play into formal home instruction also require particular attention.

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