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Model-Based educational technique to develop mathematical concepts in preschoolers

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Abstract

The article presents the results of a ten-year multi-stage pedagogical experiment on the development of mathematical concepts in hundreds of preschool children. It was proved that modeling should be considered as a methodology for the development of mathematical concepts in preschoolers. On the basis of this approach, an educational technique was developed for teaching mathematical concepts to preschool children. The result of teaching children with the technique is consistently high and has a prolonged effect. In conclusion, mathematics is a simple and understandable subject for the child where he can achieve significant success.

Keywords: Technology, Mathematical Concepts, Mathematical Abstractions.

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Procedimiento Educativo Basado en Modelos para Desarrollar Conceptos Matemáticos en Niños Preescolares

Resumen

El artículo presenta los resultados de un experimento pedagógico de múltiples etapas de diez años sobre el desarrollo de conceptos matemáticos en cientos de niños en edad preescolar. Se demostró que el modelado debe considerarse como una metodología para el desarrollo de conceptos matemáticos en preescolares. Sobre la base de este enfoque, se desarrolló una técnica educativa para enseñar conceptos matemáticos a niños en edad preescolar. El resultado de enseñar a los niños con la técnica es consistentemente alto y tiene un efecto prolongado. En conclusión, las matemáticas son un tema simple y comprensible para el niño donde puede lograr un éxito significativo.

Palabras Clave: Tecnología, Conceptos Matemáticos, Abstracciones Matemáticas.

1. INTRODUCTION

The methodology is usually defined as the system of principles and methods of organization and construction of theoretical and practical activities (from the method and the Greek logos – word, concept, and teaching). In modern scientific knowledge, the term methodology refers to three different levels of the scientific approach (Slobodchikov, 1994). The first level is some general philosophical approach, common knowledge, taken by the researcher. The second level of the methodology of scientific knowledge is represented by a private (or specific) methodology, adopted as a set of methodological principles used in this field of knowledge when building the theoretical basis of activity. The third level is the methodology as a set of specific methodological techniques in practical activities. The methodology is divided into general and particular ones. The general methodology formulates some of the most general principles that are consciously or unconsciously used in the construction of the theoretical basis of practical activity. As a general methodology, one or another philosophical system is usually adopted, for example, idealism, materialism or dualism. The answer to the basic question of philosophy depends on the choice of the philosophical system: the problem of the attitude of thinking to be, consciousness to matter. Any philosophical system is a specifically developed solution to this problem, even if the core issue is not directly formulated in it (Rosenthal and Yudin, 1963).

For quite a long time, pedagogical and educational theories were considered fields of knowledge independent of philosophy. However, it cannot be denied that they are directly related to specific philosophical problems, in particular, with the problem of the relationship between the subject and the object (subjective and objective, ideal and real). Methodology as a doctrine of the method of scientific knowledge and transformation of the world Rosenthal and Yudin (1963) requires a theoretical substantiation of the possibility of this knowledge either by the laws of the objective world, or by the laws of spirit and idea, i.e. a set of rules arbitrarily created by the human mind. On the other hand, a method is the movement of the content itself (according to Hegel) and therefore cannot be developed outside the content. The method of knowledge can only be scientific when it reflects the objective laws of reality itself. Therefore, the principles of the scientific method, its categories and concepts are not the sum of arbitrary rules created by the human mind, but are in accordance with the objective laws of nature and society, which makes it possible to link them with the practical influence of the subject on the objective world.

The development of the second level of the methodology of scientific knowledge – the specific methodology. Andreeva (1997) believes that specific methodology is the realization of philosophical principles as applied to a specific object of study. According to Hegel, this is the movement of the content itself. The level of private or special methodology of scientific knowledge in the framework of the theory of teaching mathematics can be attributed to three series of problems: the question of the essence of the mathematical development of the child; the problem of the relationship between teaching subject knowledge and the process of mathematical development; the problem of developing specific technologies for teaching the child mathematics (the formation of concepts and methods of action with them) based on the chosen methods for achieving the stated goals.

The position of the first two problems directly depends on the position of the developers of programs and technologies for teaching mathematics, as well as the position of the teacher who implements the process of educating and teaching the little man. The degree of elaboration of the third problem depends on the productivity and developmental effect of the process of studying the mathematical content at preschool age, as well as the degree of professional (methodological) comfort of the teacher when working on the appropriate program. In Russian, to refer to this level of methodology, the notion methodology proper is more often used. However, reducing all methodological problems to only the third value is considered unacceptable. Whatever empirical or experimental methods are used in the study, they cannot be considered in isolation from the general and specific methodology of this field. Obviously, the same can be said about the techniques that occur in the learning process. They are always applied in a certain methodological key, or as they say, in the framework of a methodological concept. In turn, the philosophical principles cannot be applied in the research of each science directly: they must be refracted through the principles of a special methodology.

At the same time, specific methodological techniques can be relatively independent of methodological principles and applied in practically the same form within different methodological orientations, this is due to their common content (in our case, this is the mathematics as an academic subject). However, the general set of techniques, leading the strategy for their application, of course, carry a methodological burden, defined by the concept of building this methodological approach. Today in preschool education there is no general methodological approach to the problem of the mathematical development of a child of preschool age, as a result, the methodology is limited to the framework of a particular method of forming elementary mathematical concepts and a set of specific subject skills (counting, computing, measuring, etc.), which led to that the sets of specific teaching methods created in the framework of various kindergarten educational systems were considered as existing by themselves, beyond that (at least some) general and special methodology for this area.

Such a situation could not lead to a violation of successive relationships in the child's mathematical education, to a rather low productivity of this process in terms of the requirements of school programs in mathematics, as well as to a situation of methodical uncertainty for a kindergarten teacher, since none of the existing mathematical systems Education of a child in kindergarten today does offer the teacher a truly comprehensive methodological system in which all the above-mentioned directions are developed. Moreover, most of the authors of the programs, offering modified mathematical content (often significantly expanded in relation to the provided training program for the teacher in a college or university), do not offer appropriate methodological support even at the level of a private methodology, recommending the teacher to independently develop it, focusing on their own knowledge of the subject (mathematics) and experience with children. Real practice shows that the direct organization of developmental education in the subject-specific classes (including mathematics) is a significant challenge for a kindergarten teacher. Even in elementary school, fifty years of attempts to implement developmental education have shown that fluency of a teacher in developmental learning technologies on subject content requires a significant restructuring of the teacher's methodological thinking, as well as the formation of a special systematic methodical thinking of the teachers in their educational technology (Istomina, 1995).

It is also worth noting that the traditional understanding of the question of methods by pedagogy usually means the second level of the methodology of scientific knowledge, represented by a private (or special) methodology, taken as a set of methodological principles used in a given field of knowledge - this is how to teach to achieve one side of high educational results, and on the other hand - to comply with the principles of developmental education, which focuses on the development of the thinking of the child being taught. Initially, the main programs developed in the theory and psychology of developmental education were concerned only with primary school education and aimed at the general mental development of a student (Zankov, 1990), as well as the development of a child's theoretical thinking style Davydov (1986) and Elkonin (1979), Further, studies by Galperin (1959) and Obukhova (1972), devoted to the patterns of thinking development in childhood, showed that a preschooler can also successfully solve a sufficiently large circle of productive intellectual tasks if the learning process is properly built. The basis of the approach developed by them was the theory of Galperin (1959) about the gradual formation of mental actions.

At present, the problem of developing creative thinking has begun to attract increasing attention of psychologists and methodologists, and as a result, attention has been focused on the so-called cognitive learning, the purpose of which is the development of creative abilities, the release and use of the latent creative potential of the child, and stimulation and development At the same time, all researchers almost unanimously agree on the need for the formation and development of a child’s special cognitive structures (Piaget, 1994), which characterize a person’s cognitive behavior (meaning subconscious logical structures that direct thinking); and also, the formation of a child's system of concepts –a hierarchical grid of parallels and meridians, in which concepts are distributed and mutually correlated depending on the degree of their commonality and similarity (Vygotsky, 1935). In this case, the system of concepts will represent is a more or less internally ordered hierarchical structure, rather than the indiscriminate conglomeration of a fairly significant amount of facts and information that a preschooler often possesses, but all this facts and information are scattered, taken only by memory, and this leads to the fact that the general level of both the mastering of knowledge and the mental development of a preschooler before entering school leaves much to be desired.

In this regard, Bruner (1962) puts forward a hypothesis rather unusual for preschool pedagogy: any subject can be taught effectively and in a sufficiently adequate form to any child at any stage of development. To make this possible, one should take into account that at each stage of development a child differs in a certain characteristic way of seeing the world and explaining it to himself. The task of teaching a child at any age is to present the structure of the subject in terms of the way a child sees the world. Developing this position, Wenger (1969), exploring the processes of formation of preschooler thinking, notes such a specific mediated form of thinking as modeling, which, being formed in special training, later appears as a universal general intellectual ability of a child, and moreover, as the main means of productive intellectual activity of a preschooler. Thus, modeling is possible just the very adequate form (methodology of training and development), corresponding to the ways of seeing the world and explaining it to oneself characteristic of a child at the preschool stage of age development.

This provision is in accordance with the views of the Russian psychologists on the success of the process of formation in a child of mental activity and the development on this basis of other mental processes, due to the inextricable link with external objective activity. This position, in turn, is determined by the method of solving the basic question of the philosophy of knowledge - the relationship between the objective and the subjective, thinking and being, consciousness and matter. From the very birth of a child, objects created by people, language and the ideas and ideas reflected in it are surrounded. However, its development does not occur by adapting to the world, but by appropriating the experience that has been accumulated by mankind throughout public history (Leontyev, 2000). Such a process Leontyev called assimilation and noted that in order for assimilation to occur, it is necessary to carry out activities adequate to that embodied in a given subject or phenomenon. Activities that adequately reflect the one that is embodied in the studied subject or phenomenon are called modeling, it is carried out not directly with the object being studied, but with its model.

2. METHODOLOGY

A model is usually understood as a certain system that corresponds in some respect to a simulated process or phenomenon, and covers such essential features of this process or phenomenon that correspond to the goals of modeling and enable the subject to receive new information about this process (Davydov, 1972). Under the simulation, thus you can understand the way to build a model. The main thing that needs to be taken into account when choosing a modeling method is that the model should reflect only those of the essential properties of the phenomenon that is necessary to realize the goals of the work for which this model was built. When using modeling in the learning process, one should take into account the psychological identity of each stage of the child's development and act in accordance with the characteristic way of seeing the world by the child and the way of explaining it to himself.

Thus, modeling can act in various functions: as an object, as a method, as a means of knowing the world around it. The very same model (which is an integrally studied object) allows emphasizing its essential qualities (this happens in the process of modeling by abstracting from the insignificant properties and qualities of the object) and interrelations with other objects. The condition for the success of this method of cognition is the possibility of materializing the model at different levels: real (layout), figurative (representation), schematic (drawing, diagram), verbal (description in speech), symbolic (signs, letters, symbols, and their combinations).Since the activity of modeling is in its essence adequate to that embodied in the studied subject, one can speak of its decisive influence on the formation of mental activity and the development of all mental processes. In the study of mental processes, it was established that their internal structure is closely connected with the structure of the corresponding external action, the mental process as it was built according to the type of the corresponding external activity. It was proved that the formation of a new mental action must begin from a psychologically original external material or materialized form, in this connection Galperin (1959) wrote that only the material (or materialized, that is, embodied in the scheme or symbols) form of action can be a source of full mental action. The first task of teaching every new mental action is, therefore, to find the original materialized form of this action and accurately establish its actual content. Methodologically, such external factors and forms are objectively controllable and manageable; therefore, they can be considered as a means of training and active influence on the formation of mental activity and other mental processes.

At the same time, the structure of the thinking process and the specificity of its flow in a preschool child should be taken into account both when choosing the level of materialization of the model and when developing a system for modeling the child's actions with it, which is the exact method (technology) of teaching the child-specific subject content (Davoudi et al., 2018; Fartash et al., 2018; Karlina et al., 2019). The developing effect of modeling when working with a preschooler is explained by the fact that one of its main functions is to provide a visual basis of the former mental action, i.e. the model serves as its external support, helping the child to understand the structure of the object being studied, to correctly build a sequence of modeling actions and, accordingly, to build the course of reasoning according to the same logic. Taking modeling for a preschooler in mathematics as the leading method, we can proceed to the third level of methodology: developing a set of specific methods for teaching a child to mathematics based on the method chosen (and here private methods of familiarizing with a number, with arithmetic action, with geometric figures, etc. are already being developed), i.e. all program content), which is actually a specific method of teaching a child to a given subject (simulated) content that is directly used in class.

Obviously, the choice of the modeling method and the type of model is due to the age characteristics of the preschooler's thinking and perception, which are not the same at different age stages. A 3-5-year-old child is characterized by visual-effective thinking (i.e., thinking that is activated in the process of activity) based on a developed sensation, which is fulfilled in the course of actions with objects. Therefore, teaching models at this age should be real, allowing for full sensory perception (not only see, but touch, feel, perform manipulations, etc.). The main difficulty lies in the teaching of mathematics: the study of mathematics is connected not with the study of specific subjects, but with the study of abstractions. The set, number, geometric figure, arithmetic action, etc. are the concepts of a high degree of abstractness and generality. Therefore, there is the problem of building for the child adequate models of these concepts. An even more important problem is the construction of a system of modeling actions of a child, connected not only with the study of the model proposed to him, but also (most importantly!) allowing the child to build the model of this concept himself, and through the process of its construction to realize the basic properties and relations of the mathematical objects under study. To solve these problems, the teacher must be well proficient in matters of mathematical content, and have the experience (ability, talent) of inventing appropriate modeling actions.

Children at the age of 6-10 are characterized by visual-figurative thinking, i.e., to activate it, such an organization of images is necessary that allows them to see and highlight the most essential in objects, as well as to see their correlation with each other and the ratio of their parts. Visual-figurative thinking style is characterized by the fact that for its activation it is necessary to have a visual image, a visual model (figure, diagram), reflecting the essential features of an object or all objects from the scope of a given concept. Therefore, the teacher should be able to make (draw) such a model. At the same time, the model itself technically can be very simple: for its construction both various didactic (handouts) materials, and paper, wire, specialized didactic sets (for example, geometric bodies) are used; textbooks for children in the form of notebooks, which have recently become very popular in preschool education, can also be used (provided that these manuals contain the models necessary for the teacher). In other words, a model is not only and not so much illustrative material, but rather a means of organizing a problem situation, but at the same time a way to solve it, as well as a means and way of organizing a child's research activities in studying mathematical concepts and relationships. The methodological task is to find the materialized form of this action and build a system of modeling actions of the child in accordance with its actual content, which will ensure the internalization (transition to the internal plan) of an adequate course of action or concept image.

Below we give examples of building concrete methods of a teacher's actions on the basis of the presented methodological basis. Let us show on a specific fragment of the lesson the application of this methodological approach in the form of a system of modeling actions of the child, organized by the teacher during the lesson. Below we describe a fragment of a lesson for 3 y.o. children: topic Count to three. When studying topics of this type in the classroom, one can very often ask the question how many are there/how many do you have? Teachers always say: How many windows are there in a room? How many pots with flowers are there on the window sill? How many dolls are there on the couch? etc. In all these cases, a child performs the same account activity in a familiar situation. The activity is reproductive since the child needs to recall the method of counting objects, which he was taught on similar examples (Christmas trees, bunnies, ducks, etc.), i.e., recall the names of numerals and the order of their naming, and apply existing knowledge to a similar situation.

We suggest making the child's activity productive, i.e. we will formulate tasks in such a way that the children have to think about how to apply existing knowledge to a new situation (we will formulate tasks in the form of a series of problem situations). To do this, the teacher will need to specifically provide for the organization of the visualization used. There should be three pots of flowers on the windowsill (the rest should be removed from the sight of the children). For the organization of independent activities of children with objective visibility (modeling), we set a small box in front of each child with six counting sticks of two colors, for example, three red and three green ones. The quantities of the same color must be the same. A teacher needs a flannel graph, or flannel board (a piece of plywood, covered with flannel) sized 50x50 or 40x60. Instead of sticks, a teacher uses small strips of velvet paper (models of sticks) as long as a palm. They can easily be attached to the board. A sheet of paper is also needed (it will play the role of a screen); for it to hold on the board, stick two small pieces of velvet paper on its back.

Teacher: Children, look at the window. What do you see on the windowsill? (Pots of flowers) You have boxes on the tables. What is in them? (Sticks) Take out of the box as many sticks as there are lots of flowers on the windowsill, and place them in front of you. This formulation of the question requires the child not only to apply the counting activity that can be familiar to him, but also to independently transfer the result of this activity to another set, as well as apply this result to the subject activity (independent counting of the required number of pots - this is the model of the situation the child builds on his own). Since the teacher is in front of the children, he can immediately see how the children have completed the task. At this point, you can clarify the knowledge of the word-numeral: Pete, how many sticks do you have? And you, Kate, how many sticks do you have? If one of the children made a mistake, for example, he took two sticks, the teacher asks this child to put as many sticks on the board as he has on the table. Children usually like to work on the board and they are happy to carry out the task. The teacher offers the child to verify the number of sticks on the board and the number of flower pots on the window sill. This is usually sufficient to correct the error, since the comparison of these two quantities is based on a one-to-one correspondence. The teacher once again clarifies: so how many sticks are there? (Three). Teacher: Children, look at your sticks. Who has all three sticks of the same color? Since the sticks are selected according to the colors indicated above, one of the children will have either three red or three green sticks.

- What color are your all three sticks? (Red) And yours? (Also red) Who has three green sticks? Make sure everyone has three green sticks.

- Now, pick up one red and two greens sticks. How many sticks do you have now in your hand? (Three)

- Now pick up two red and one green stick. How many sticks do you have now? (Still three.)

This stage is aimed at understanding the number three (two and one, one and two). Teacher: Now let us play the Guessing Game. The teacher comes up to the flannel and covers the sticks on it with a sheet of paper (screen). How many sticks are hidden behind the sheet? (Three.) The teacher pulls out one stick from behind the screen and puts it by the side (Fig. 1):

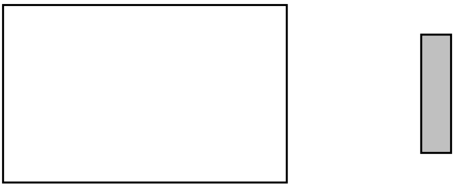

Fig. 1

- How many sticks are now hidden behind the screen? (Two) Shall we check? The teacher removes the screen the children see that there really are two sticks. The teacher puts the screen back. He takes out another stick and places it next to the screen (Fig. 2):

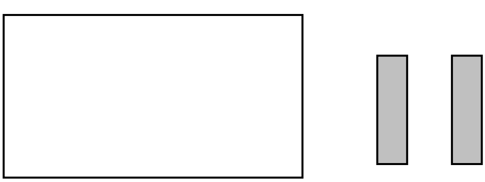

Fig.2

- Now how many sticks are hidden behind the screen? (One) The verification is similar.

This stage of the assignment reinforces the knowledge of the number three, and also prepares children for acquaintance with the action of subtraction in perspective.

Teacher: And now we will try to add something from these three sticks.

The game can be held in two versions: by the type Monkey - the teacher creates various shapes of three sticks on the board, and the children repeat them on their tables, or by the type Do it yourself - the children themselves come up with different designs of three sticks and stitch their own design on the board (Fig. 3). We try to come up with a name for each structure if possible:

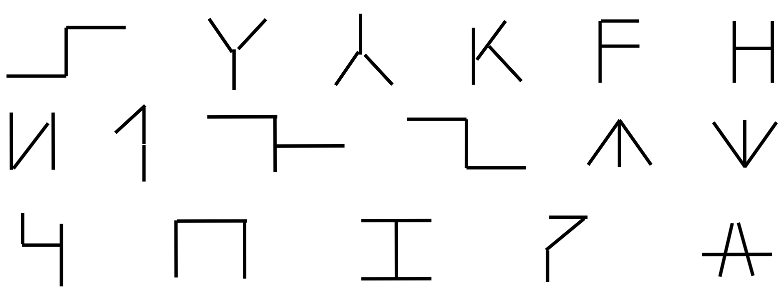

Fig. 3

This stage of the task develops spatial thinking, imagination and constructive abilities.

One of the children will surely make a triangle.

What is it? (Triangle) Who knows why it is called like that? (Three angles - the teacher helps to show the top with a finger, three sides - the child runs his finger along the side).

The teacher offers children a stencil with slots in the form of geometric shapes for each child (Fig. 4), some sheets of paper and colored pencils:

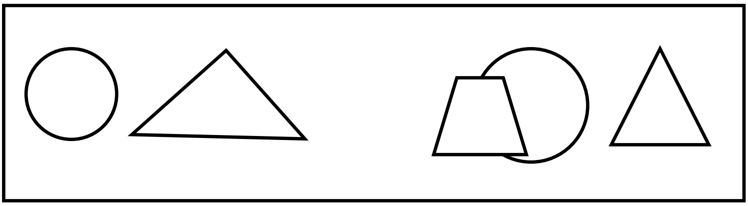

Fig.4

Task: Find a triangle on the stencil. Circle it. Paint over the stencil.

- How many shapes can you see on the stencil? (2).

- Mr-Know-Nothing thinks that this picture is also a triangle (Fig.5):

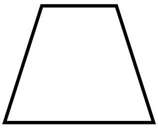

Fig.5

- Who will explain to him that he is wrong? (4 corners, 4 sides).

- Who was wrong like Mr-Know-Nothing? Cross out the wrong shape.

- Circle a large triangle in red pencil by hand. Blue pencil is for a small triangle.

- Look at the cats. (Fig. 6). How many of them do you see? What do they look like? (Circle and triangle in the figure of each cat). What is the difference? (Big and small cats: a mother and a kitten. The biggest cat is a dad).

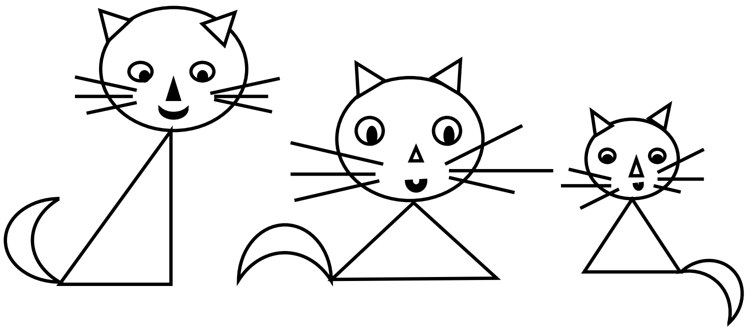

Fig. 6

- Draw the same cats using a stencil and paint them over.

The assignment teaches you to recognize geometric shapes as part of the design. This develops constructive skills, attention and imagination, hand-eye coordination and fine motor skills. As you can see, all the tasks are organically interconnected, arranged around one problem, which has been indicated in the topic of the lesson. In addition, each stage has its clearly identifiable goal, the achievement of which the teacher sees immediately, assessing the results of children's independent activities (modeling). Throughout the lesson, the activities of children are productive and meaningful; memorized patterns of actions or answers are not used at all which meets the modern requirements of developmental education. Describing the full-fledged modeling activity of the child, it is possible to identify and summarize the actions that are part of this activity. In its composition (regardless of the material on which it is formed), the following types of modeling actions can be distinguished:

a) Visual assessment of the given objects;

b) Selection of the type of model corresponding to this task (this task);

c) Transference of the resulting verbal or visual information into a model of the selected type (schematic, graphics, real, mental, symbolic);

d) Transformation of the model in accordance with the goal (educational task);

e) Analysis of the results obtained on the basis of the correlation of the original object with the object obtained as a result;

f) Transference of the results to an extended set of objects of this type.

In the process of performing each specific task, it is not always possible to follow all the listed actions even when working with children of school age. However, the formation of a full-fledged modeling activity cannot occur simultaneously, therefore at various stages of its formation, it is possible to implement at least 2-3 modeling actions in one or several interrelated tasks. In this case, the modeling activity of the child becomes a process, each subsequent step of which is caused by the result of the previous step. Such an approach to the organization of the development of the child's modeling activity will ensure its continuous upward movement towards usefulness. Let us give an example of such a construction of several interrelated tasks in a class with children of 3-4 years old. The topic of the lesson: Geometrical figures: a triangle and a square. Didactic goal: to clarify the form of geometric shapes (triangle and square), to develop calculating skills, to develop constructive thinking, imagination, attention, perception and self-control.

Task 1: Using drawings of the characters, the teacher organizes a storyline situation: Once there lived a cat Kotausi and a mouse Mausi – they are shown below (Fig. 7):

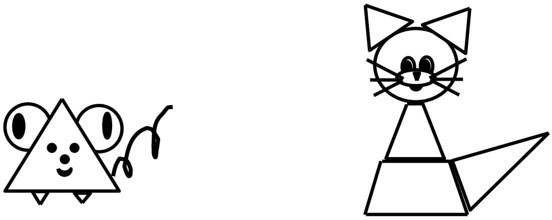

Fig. 7

- Let us make a house of a mouse Mausi. Here it is (Fig. 8):

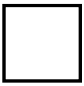

Fig. 8

The teacher puts a square on the board. Children make a square on the tables with the help of counting sticks.

- Make a house for the cat Kotausi - the same, but larger.

In order to make a larger square, you need to take two sticks for each side. You should wait for the results and compare the resulting houses, bringing the children to this conclusion. After that, you can suggest that someone from the children lay down a house for Kotausi on the board.

- Who lives in a small house? (Mausi) Who lives in a big house? (Kotausi) Images of the characters are placed in the houses on the board. Children use big and small pictures for their characters. The teacher reads the children a poem by Marshak about Kotausi and Mausi.

Task 2: The teacher continues the story:

- It started to rain, and in the house, at Mausi there is no roof. Build a roof on a small house. Who wants to build a roof on the board?

- Build a roof on the house Kotausi. Can you build the same roof? Why not? What roof should we build? (A bigger one) (Fig. 9).

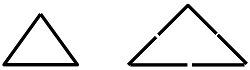

Fig. 9

- What is the difference between two triangles? (One is bigger, another one is smaller)

-Compare the houses: What is the difference? (They differ in size - one is big, another one is small) How are they similar? (Houses are of identical shapes). (Fig. 10).

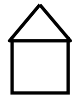

Fig.10

Analysis of the example: In this series of tasks, all five types of modeling actions are implemented, including transferring the results to an extended set of objects of this type. Objects of this type can be considered any design of the sticks that children make. In this case, all the designs they create themselves, the sample was only the first shape. All the following constructions for a child of 3-4 years old are constructive tasks of a problem-search nature. The plot organizes the motivation for children's activities. To transfer the modeling activity to a graphic level, in the next lesson, the teacher may suggest drawing Kotausi, Mausi and houses for them using a stencil with slots in the form of the same geometric shapes. The problem of recognizing the desired geometric shapes on the stencil, depicting them in the right position by turning the stencil, painting the shape by the stencil is quite a challenge for a child of this age, which turns this task into a problem-search one.

We deliberately gave examples of tasks for 3-4 year old children, since this task is the most methodologically difficult: the tasks must meet the requirements formulated above, but the level of complexity must fit the child's capabilities; also, the game form must remain, which is due to the requirements for organizing the learning process with children of this age. During the ten-year formative experiment, a complete system of relevant sets of problem-search tasks was developed, providing the educational process for children 3-4, 4-5 and 5-6 years old. Experimental work with preschool children was carried out in two stages. At the first stage, the authors conducted a system of classes with preschoolers at the age of five in a regular kindergarten, systematizing and developing materials for educational work with preschoolers from 3 to 6 years old. At the second stage, methodological materials for kindergarten teachers were developed, representing methodological development of classes for children from 3 to 6 years old Beloshistaya (2004) and printed notebooks for organizing individual work with children, which contain tasks for developing the main components and qualities of mathematical thinking in accordance with the age characteristics of preschoolers (Beloshistaya, 2005; 2007). Using these teaching materials, educators who expressed a desire to take part in the experimental work worked independently for five years, annually providing the results of the final sections for comparison of the results.

3. RESULTS

The analysis and comparison of experimental data were carried out by various methods. One of the main ones was considered to be an expert assessment of educators, methodologists, and elementary school teachers as well as school psychologists who were dealing with children from experimental groups in grade 1. All of them noted that the use of materials developed in the course of research makes the process of the child's mathematical development clear and comprehensible to the teacher, does not interfere with the teaching process, allowing them to focus on the individualization of the learning process. Educators also noted the growing interest in mathematics among children of experimental groups and the desire to engage extra activities. In turn, school teachers noted that the children of experimental groups had very high-quality preparation for the study of the school mathematics course (including the content side), and at the same time these children almost always received the highest logic score at the entrance testing. A similar result was obtained by verifying the visual-motor coordination: very high rates were observed among children of experimental groups. This is an important result, since the level of development of visual-motor coordination is significantly associated with the level of development of spatial thinking, and is a complex set of motor character, the level of development of which determines further mastery of other skills.

We present the result of the last control test of the mathematical development of preschoolers, conducted in randomly chosen kindergartens. 194 children of 6.5 years old were examined. For the test, a series of test tasks (9 tasks) was developed, which included elements of standard testing for the preschoolers maturity level (quantitative representations, counting), as well as special tasks aimed at identifying such indicators of mathematical development as the formation of mental actions (analysis, synthesis, coordination); the level of development of attention, perception and memory in connection with the quantitative assessment; the level of development of perception and figurative memory in connection with the recognition and combination of geometric shapes; the ability to recognize and build a logical consequence of the given situation; constructive skills. The data are shown in Fig. 11.

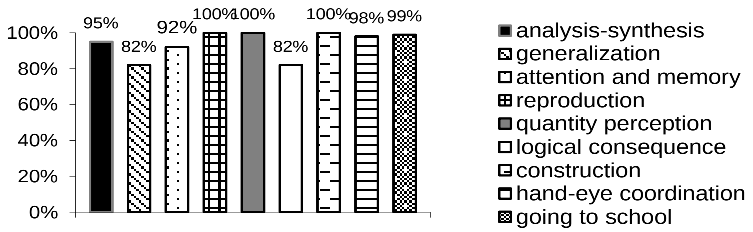

Fig. 11. Diagnostic map of indicators of the level of knowledge of children upon the end of the learning process

4. DISCUSSION

The comparison of diagnostic cards has shown that the test results among children during first three years improved significantly, and in the next three years, they remained almost at the same level with minor fluctuations (see Fig. 11). This is most likely due to the fact that the level of methodological skill among teachers has also increased significantly. In other words, teachers have mastered the methodology and content of the work well and therefore could fully devote their learning activities to the child, without being distracted by the methodological difficulties. The presented quantitative analysis, despite its simplicity, clearly shows that the level of mathematical skills among children (in the form of characteristic components of the mathematical style of thinking) increases significantly with the help of presented teaching materials, and these parameters are considered characterizing the child's ability to successfully master the mathematical content at school. The study conducted a selective analysis of the further success of these children in school in mathematics. The result of this analysis shows that during elementary school, these children successfully cope with the program. The teachers note the good preparation of children and the consistently high performance in mathematics during the elementary school educational process. Many of the children enrolled in the technology developed in the study come to gymnasium classes, since, as a rule, high results of testing these children in mathematics and logic are marked. Even in cases where, according to their inclinations or the wishes of their parents, children enter various humanitarian high schools, mathematics is not a problem for them throughout the entire period of education in elementary school. If at the same time, they get to classes where the teacher continues to work on the technology of developing the logical thinking of younger schoolchildren developed by the same team of authors (Beloshistaya and Levites, 2010), the work on the mathematical development of a child takes on a continuous succession and often in these cases, teachers of mathematics in high school mark the children of such classes as very capable.

5. CONCLUSION

Summarizing the results of theoretical and experimental research presented in the article, we have formulated the following conclusions:

1. The methodological approach designed and tested in the course of research to build a technology for teaching mathematical concepts to preschool children allowed developing a highly effective methodological system for teaching mathematics in kindergartens.

2. Since the study of mathematics is not related to the study of specific subjects (the concepts of set, number, geometric figure, arithmetic action, relationship, etc., are concepts of a high degree of abstractness and generality), it was necessary to solve the problem of constructing adequate models for the child of the concepts being studied, and also, an even more important problem of building a system of modeling actions of a child, connected not only with studying the model proposed to him, but also allowing the child to build a model of this concept himself, and through process of its construction to understand the basic properties and relations of the studied mathematical objects. These problems were successfully solved during the study.

3. The technology developed during the research is reproducible, i.e. available for the development of any kindergarten teacher, regardless of experience, work experience or material resources of the kindergarten. The only prerequisite is the use of the developed materials in the system at the stage of the entire period of the child's education in kindergarten. In this case, the starting level of development of mathematical representations in a child does not play a significant role. In the case of a low level of development of mathematical representations, its correction takes place.

4. The result of the child's education according to the technology developed in the course of the study is sustainable and allows the child to feel comfortable during mathematics lessons in elementary school, regardless of the program or math textbooks. Mathematics is a simple and understandable subject for the child where he can achieve significant success.

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