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Innovative Technology Three-Dimensional Modeling In The Digital Environment LigroGame For The Development Of The Natural – Mathematical Concepts In Preschool Children

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Abstract. The article discusses the possibilities of electronic content modeling 3D LigroGame for the development of children's natural and mathematical concepts in the framework of the activities of the author's program of additional education "Play and model in LigroGame".

The development of natural and mathematical concepts in preschool age is currently an important topic, which is considered by many experts in the framework of the so-called STEM – approach – educational international direction, designed to create conditions for the formation of early forms of career guidance for science-intensive and engineering specialties. This global trend is associated with the increasing importance of human resources for the complex technological world, where the importance of raw materials is reduced due to new economical and environmentally friendly solutions based on nano-and IT-technologies. In this regard, there is a need for specialists in high-tech and natural Sciences, specialists with innovative thinking and potential, able to solve non-standard problems and offer modern engineering solutions based on their ideas and hypotheses.

The main place in STEM (abbreviation of Science – natural Sciences, Technology – technology, Engineering – engineering, design, Mathematics – mathematics) is given to practice, connecting disparate natural - scientific knowledge into a single whole [2].

At the same time, educational institutions are experiencing difficulties at the stage of choosing programs and means of training for the implementation of this direction in the context of practical activities with children. In the theory and practice of natural-mathematical, early engineering education of children there are significant difficulties and contradictions, expressed in the awareness of teachers of the need to abandon the traditional way (obsolete programs, techniques, traditional learning technologies, etc.) and the beginning of the search for a new one. In the pedagogical literature of previous years, the concept of "engineering thinking", as a rule, is considered only as a type of cognitive activity aimed at research, creation and operation of new high-performance and reliable equipment, advanced technology, automation and mechanization of production, improving product quality. Engineering activity is considered in close connection with the industrial stage of technological production. At the present stage, engineering is interpreted as a broader concept: the design of materials, cells at the DNA level, the reproduction of the functions of living systems, etc., which increases the value of natural science concepts. The changes taking place in the modern digital society increase the demand for the level of digital competence of the specialist.

In these conditions, the development of electronic forms of education of preschool children, the use of digital learning tools (computers, tablets and others) for the formation of basic digital skills (competencies) and skills in preschool age becomes relevant in preschool education.

Modern research in the field of preschool pedagogy K. N. Motorina, S. P. Pervina, M. A. Kholodnaya and S. A. Shapkina [1] and others testify to the possibility of mastering the computer by children aged 3 to 6 years as an instrument of activity. As you know, this period coincides with the time of intensive development of the thinking

child, preparing the transition from visual-figurative to abstract-logical thinking and reflection, the opportunity to predict the result, enhances the design quality of thinking. Domestic and foreign studies of computer use in preschool educational institutions convincingly prove not only the possibility and feasibility of these technologies, but also the special role of the computer in the development of intelligence and in the whole personality of the child (research of S. L. Novoselova, I. Poshalite, G. P. Petku, B. Hunter et al.).

Project team – A. V. Molodnakova (specification, methodological part), M. V. Poryvkin (programmer), G. V. Malkov (programmer), V. A. Kovyazin (design). We developed innovative software for computer simulations in planar and three-dimensional environment, which was given the name "LigroGame". This solution implements in an elementary form the technology of modern engineering design for the implementation of objects on 3D printing and is a radical innovation for the education of preschool children. Currently, the innovative project is being tested in five state preschool educational institutions of the Sverdlovsk region on the terms of network partnership.

In the framework of innovative projects for preschool children have been introduced to the program of natural scientific and technical directions, "Playing and simulated in LigroGame" (author A. V. Molodnyakova) with the game teaching materials for classes. The main purpose of the additional program – in the process of cognitive and constructive modeling activities to form in children the basic skills of modeling 2D and 3D objects in the electronic environment LigroGame, where the resulting computer models can be implemented through 3D printing or format 3D AR/VR objects.

The program includes three educational modules, the first of which provides the formation of systematic representations of objects of living and inanimate nature on the basis of the basic model OTSM – TRIZ – "element of the world – sign – value sign" (EPZ). The second and third modules of the program form children's skills of computer modeling of objects based on the morphological matrix of the project, starting with elementary models and ending with detailed thematic children's game projects.

The following diagnostic tools were selected for psycho – pedagogical monitoring of the additional program:

1. To assess the level of formation of sensory representations: the method of "Stripes and circles in different colors" (an adapted version of the methodology C. D. Zabramnaya), the technique of "Box shapes" (an adapted version of the methodology of E. A. Trebeleva), the technique of "Inclusion in a row" (an adapted version of the methodology A. Wenger), the technique of "What's what?"determining children's knowledge of material values;
2. For the analysis of products of computer 3 D modeling the technique of the analysis of products of children's activity is adapted.

This monitoring on a group of children enrolled in the additional program "Play and model in LigroGame" allows to make an objective assessment of the effectiveness of the use of 3D modeling technology for cognitive activity of children of middle and senior preschool age.

To master the technology of computer modeling in preschool children, a method of teaching was developed on the basis of the basic model OTSM – TRIZ – "element of the world – sign – value sign" (EPZ), which is based on the study and description of the objects of the real environment of children in the original game. The technique includes the technology of the game with basic physical characteristics by means of key questions of each characteristic – character, definition of values of the characteristic and drawing up the scheme of the model on the basis of the tool of TRIZ – morphological matrix. This approach makes it possible to form a systematic representation of the objects of the surrounding world in preschool children, which are imprinted in the minds of children on the basis of sensory experience, and to transfer this representation to another reality – virtual, in which the child also operates a system of signs necessary for the creation of 3D models.

Ref. [5] – Modeling is the study of objects of knowledge on their models. We can consider modeling as a process of research, where the basis of the activity is the construction of a model on the given information features. For preschool children, the first information signs are sensory standards that children study on the objects of the real environment: color, shape, size, material and other physical characteristics of objects. In our program, information signs are game characters that emotionally involve children in cognitive activity.

Introduces children to the signs – characters the main character of the educational program – Ligrenok – a curious and mischievous character who loves to do "little discoveries" and create a new toy for their games. Each feature is defined by the image of an animal or insect, the biological property of which should cause Association in children with the designated feature. For example, the sign "color" is indicated by the image of a chameleon – a living creature that adapts to the environment by changing color. This biological property was used to create didactic and outdoor games for the study of color, where children, for example, determine the objects of the real

environment, which can "hide" chameleon" a certain value of color. Thus, this didactic method expands children's understanding of the properties of biological systems, objects of wildlife, their biological properties.

These games are aimed at the formation of children's system of perceptual actions and sensory reference system based on the basic model of EPZ and include the accumulation of information about the features that are used in the process of creating an object model in the electronic environment LigroGame. In the educational activities of the additional program, the teacher uses tools to describe the object – "morphological matrix", "piggy Bank of sign values" and other tools of research activities OTSM-TRIZ.

Within the framework of the program of additional education of children "Play and model in LigroGame" electronic content LigroGame is presented as a working environment for plane and three-dimensional modeling and contains tools that allow children to make changes with objects through the values of such features as color, size, material and other features. These techniques are borrowed from the game didactics OTSM – TRIZ and give the child the tools and techniques of change and the creation of new objects in the framework of constructive modeling or research activities.

The technology of gaming computer 3D modeling in LigroGame is an innovative and modern technology for the development of cognitive activity, implemented on the basic methods of mathematical modeling, which our project team has adapted for children from 4 years and older.

To create objects in the 3D environment LigroGame children are offered basic three-dimensional geometric shapes, constructive modeling activity which allows you to create a 3 D model on the model or design. This form of modeling refers to the technology of mathematical modeling, which means "the organization of the teacher heuristically oriented process of creating child models through simple planar and spatial mathematical abstractions" [4].

TABLE 1. The process of development of cognitive abilities of preschool children in the framework of mathematical modeling

Age	Abilities	
Sensory	**Intellectual**	**Creative**
Junior – Parts identification models with touch standards	Substitution	Objectification
Average – Correlation of the finished model with the standard	Manipulation of ready-made models	Symbolization
Senior – Modeling perception	Creating models	Detail

According to research by P. Y. Galperin, L. F. Obukhova, T. V. Turuntaevo, D. B. Elkonin et al., development of mental actions occur successfully in the process of mastering by children by means of highlighting significant relationships beyond their immediate perception. Mathematical modeling is one of such tools. Learning how to use models, children discover the field of mathematical relations at the level of such important concepts as number, quantity, form, quantity, order, classification, serialization" [4].

At the first stage of mastering the technology of computer modeling, the teacher offers children to learn the techniques of object transformation using the LigroGame web application, where the environment for plane modeling is implemented. Planar modeling involves visualization of the model in one plane and gives a schematic representation of the object, acting as its Deputy.

Manipulations with a flat object "ball" allow to study the basic techniques of object transformation on the features used in the program: color, size, material, sound, quantity.

Implemented methods of transformation of feature values in the web environment on flat forms:

- replace color values;
- decrease/increase object size;
- sound overlay.

Taking into account that visual visualization is of great importance for preschool age, this method of mastering the methods of object transformation is appropriate for age and creates conditions for children to master these methods at the level of the internal action plan.

Web application LigroGame that implements the techniques of planar modeling methods of conversion of characteristic values is more exploratory in nature to gain children practice modeling. The main learning environment for computer simulation is implemented in an open-type environment – 3D LigroGame PC – version for Windows 7, 8, 10, MacOS.

Electronic environment for 3D modeling LigroGame has an original interface with the visualization of game characters, which implement certain functions of the software to change or assign from the gallery values of color, material, shape selection, change the size of the form in three quantities: height, width, volume. On the working field, children place three-dimensional geometric shapes from the Octopuses gallery section – a cube, a ball, a cylinder, a cone, a pyramid and other shapes that become the basis for creating the final 3D model.
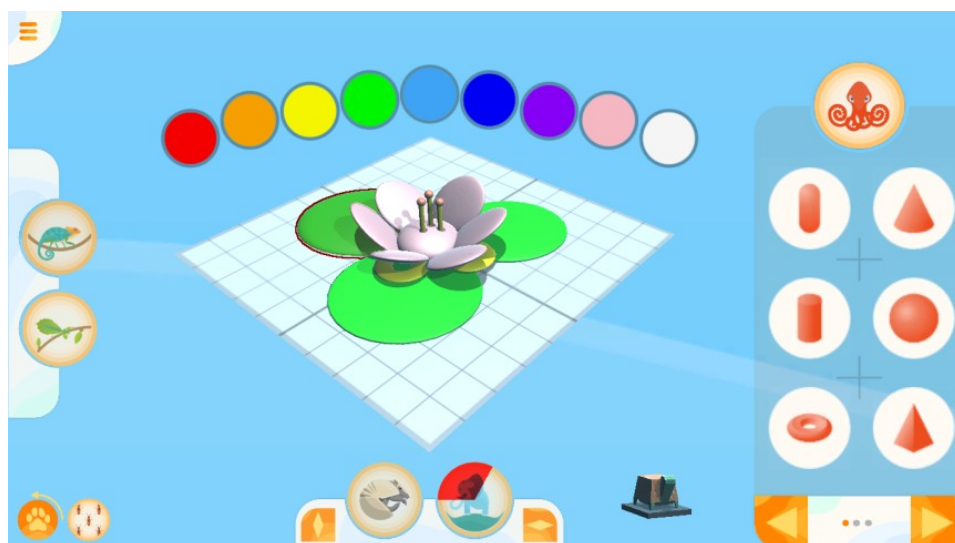
FIGURE 1. The model project «Lotus»

At the stage of mastering the activities in the three-dimensional environment LigroGame teacher conducts with children playing mathematical experiments that allow children to master the capabilities and functions of the virtual environment. For example, the experiment "Turtle plays with Octopus" introduces preschoolers to the indicator of the object position in a three-dimensional environment, which is visualized for children in the form of "turtle". The position of the "turtle" allows preschoolers to identify five spatial positions of the object on the desktop LigroGame: front view, left view, back view, right side view, top view. This is a very important observation for preschoolers, which they fix in the game schemes of mathematical experiment. During the experiment, children learn that the three-dimensional form can have a different flat value in each position on the virtual environment LigroGame.

This is one example of children's activities on the development of the features and functions of the three-dimensional environment LigroGame in the process of training activities.

This activity develops in middle-aged and older children not only natural – mathematical, spatial representations and complex cognitive functions, children learn information technology at a new level – instrumental.

Computer modeling in LigroGame involves the following educational levels:

- transformation of feature values on a flat object using OTSM – TRIZ "fantasy" techniques,
- creation of a model based on three-dimensional primitive forms,
- the creation of a model according to the plan on the basis of three-dimensional shapes – primitives.

When creating 3D models for design use the techniques of fantasy, where children are first schematically depicted in the figure, the idea, after which "write" by game characters – signs to create the skeleton of the project.

These examples demonstrate the universality of the electronic 3D environment LigroGame for various forms of children's activities in preschool and additional education of children: from didactic games to children's game project, designed with all stages of the life cycle of the project based on additive technologies. Currently, LigroGame software is an Exhibitor of the project "Preschool laboratory" at the Moscow center for quality education in Moscow, which presents modern solutions in the field of preschool education.

FIGURE 2. The model project «Snail»

FIGURE 3. The 3D model project «Snail»

FIGURE 4. Puzzle game based on 3D objects LigroGame on the theme «Martian Chronicles»

The first results of testing the additional program "Play and model in LigroGame" (36 hours) and the technology of computer game 3D modeling LigroGame on the basis of five pre-school educational organizations show the formed age capabilities of children of middle and senior preschool age on the method of analysis of products of children's activities:

- compliance of 3D model with the sample made by means of a morphological matrix in 87% of respondents;
- preparation of 3D model based on 2-3 basic forms of the sample in 91% of respondents;
- preparation of 3D models based on 3 or more forms on the model of 78 % of respondents.

In conclusion, it should be noted that specialists need to be aware of the fact that technological and natural-mathematical education of preschool children at the present stage can be fully implemented only with the use of high-quality educational electronic content that implements the instrumental level of activity.

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