Development of engineering thinking of preschool children through innovative 3D modeling technology in LigroGame

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Development of Engineering Thinking of Preschool Children Through Innovative 3D Modeling Technology in LigroGame

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Abstract. The article discusses the possibilities of innovative technology 3D modeling in LigroGame for the development of engineering thinking of preschool children in the framework of the additional program "Play and model in LigroGame", provides examples of creating children's projects on the model "invent-design-implement-manage" based on computer 3D modeling and additive technologies.

Currently, the current direction of development of modern forms of technical creativity of children is the so – called STEM – approach-an educational international direction designed to create conditions for the formation of early forms of career guidance for science-intensive and engineering specialties. The implementation of this direction in the domestic pedagogical practice has certain difficulties associated with the methodology and means of training, which should be focused on the conceptual foundations of the STEM-approach, (abbreviation of Science-natural Sciences, Technology-technology, Engineering-engineering, design, Mathematics-mathematics) where the practice is supposed to combine disparate natural-scientific knowledge into a single whole [1].

A group of domestic developers (Molodnyakova A.V., Motalov P. S., Kovyazin A.V.) has developed an educational solution for STEM education, which consists of an electronic constructor for 3D modeling LigroGame, an additional program of natural science and technical orientation "Play and model in LigroGame" (author Molodnyakova A.V.) for children of preschool age and primary school. Children's products are sold in the format of 3D print objects or AR/VR objects. Constructively-modeling activity of children in 3D LigroGame is realized on elementary methods of mathematical modeling by means of basic geometric forms. This solution is a radical innovation for pre-school education and is being tested in the educational activities of pre-school institutions of the Sverdlovsk region, Yekaterinburg, Sukhoi Log, Nizhny Tura, Asbestos, Bogdanovich, Kachkanar, 4 of which are municipal resource centers for early career guidance of preschool children. The LigroGame project is one of the leading Innovative Infrastructure projects of the Ural Federal University. B. Yeltsin.

Electronic children's designer LigroGame implements the technology of computer modeling of objects based on the research tools OTSM-TRIZ (General theory of strong thinking and theory of solving inventive problems) and can be used in the practice of problem and research training of children of preschool age and primary school. The additional program has an original author's pedagogical methodology developed on the methodological provisions of TRIZ-technologies for the study and description of objects of living and inanimate nature and their virtualization as 3D models of different levels of complexity.

The main goal of the educational program is to develop elementary forms of engineering thinking and natural-mathematical representations of children through the game technology of 3D modeling in LigroGame.

According to experts, "engineering thinking is a system of creative technical thinking that allows you to see the whole problem from different sides, to see the connections between its parts"[5]. To form the prerequisites for this thinking, in the first module of the additional program "play and model in LigroGame", children master the basic model ,which "describes" the objects surrounding the child as a system of certain features. "All models, methodologies and technologies, that is, all the tools of OTSM – TRIZ – RTV, is based on mastering the basic fundamental of the model "object – name attribute – name value sign"[3]. Using this model in the study of the object

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world allows you to teach children to accurately and fully perceive the objects of the surrounding world, through the perception of their various characteristics and properties: color, shape, size, and so on. This model becomes a tool for cognition and description of objects of living and inanimate nature, as well as a condition for the formation of elementary inventive activity of children.

Practice of development of engineering thinking assumes mastering by children such concepts as "technical problem" and "technical result" at elementary level. At preschool age, it is important to form these concepts at the level of projects that are accessible to children's knowledge. Given example. In the long-term project " sound Laboratory "(municipal Autonomous preschool educational institution kindergarten No. 43 "Kid", Sukhoi Log) children with the support of the teacher studied simple musical instruments as a system of signs, determined the features of sound effects of musical instruments that were associated with the sign "form" and" material " of the object. With the help of the teacher, a technical task was determined for a new musical instrument: to create a new sound effect for the musical instrument "maracas". The technical result was to be a musical instrument with new technical effects.

In the first stage, the children described the object "maracas" through the morphological matrix as a system of characteristic values, the next step, this matrix was used by the children for change on the part of the "corps": the principle of replacing the shape of the hull, the acceptance of the fragmentation of the body into two parts, joined together new parts of the body, acceptance of transfer of properties or method of focal objects.

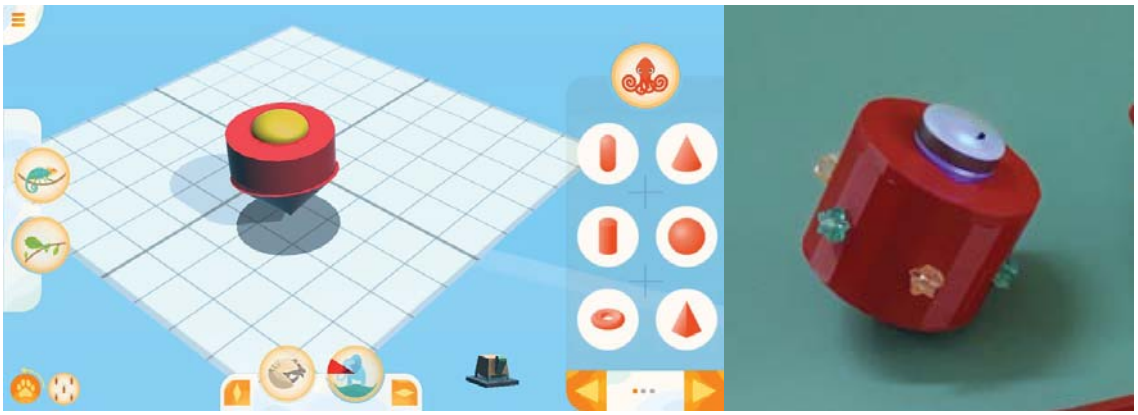
The scheme of the object "maracas" with the new values of the features of the "body" part was used by children to create a computer model in 3D LigroGame, 3D model "maracas" was implemented by 3d printing.

An example of a new musical instrument " marakas-Yula "(teacher of additional education Unesikhina Yu.G.), where the transformations of the" body " part were implemented using the method of focal objects. The "maracas-Yula" body includes three new parts: the main hollow part with a noise filler, the upper part, which is an led flashlight, and the lower part, which uses a "cone" shape for the effect of rotation. A new technical effect, which was created by combining new parts of the body: sound, optical, the effect of rotation around its axis. Thus, the technical result of creating the object "maracas-Yula" increased the range of use of this instrument: it can be used as a musical instrument in an orchestra, for playing as a top, as a means of creating an optical effect by rotating the body.

To create the object "maracas – Yula" children used mathematical modeling techniques: parts of the object were designated in the morphological matrix by means of basic geometric shapes, the shape of the parts-three-dimensional geometric shapes. In the original method of mastering the technology of computer 3D modeling in LigroGame (author Molodnyakova A.V.), children are offered geometric concepts that are mastered by them in the process of experimentally manipulative activity with three-dimensional geometric forms. This practice uses the technique of "printing" a geometric shape on kinetic sand, creating three-dimensional forms in productive activities, geometric drawing, geometric analogies and other original didactic techniques.

Mathematical representations of the properties of geometric shapes are the basis for creating an object model in 3D LigroGame, where the model is created on three-dimensional basic forms, including children learn the techniques of changing the size, spatial characteristics of the object and other mathematical representations.

The 3D model "maracas-Yula" was created using the basic shapes "cylinder", "cone", "ball" with techniques to increase/decrease the size of the forms.



(a) (b)

FIGURE 1. (a) 3D model "maracas-Yula", (b) "maracas-Yula"

At the stage of" operation "of the new object, the children measured the new technical effects of the "maracas-Yula": the stability of the object during rotation, sound effects during rotation of the object and by shaking, the properties of optical effects during rotation of the maracas and in a static state.

Thus, in the process of creating the object "maracas – Yula" preschool children have mastered the entire life cycle of product creation in the framework of the model "invent-design-implement-manage", which is the General context of engineering education according to international CDIO standards.

Evaluation of the effectiveness of the proposed method of developing engineering thinking and cognitive activity of preschool children was carried out in the process of pedagogical monitoring, which includes the method "Analysis of children's activity products". This method was carried out at the end of the school year (the 2nd year of training according to the educational and thematic plan of the additional program) on the age group of children 5-6 years old in the number of 41 people. This method evaluates the quality of children's computer 3D model based on such criteria as the structure of the object model, the transfer of the image of the object shape, the transfer of the proportions of parts of the object in the model, etc. Variants of the criteria are subject to evaluation in points. In this group, the rating in points showed the formation of criteria for children's products (3D models "caterpillar", "house", "tower", "octopus", " cat») with the following distribution of quantitative results: high level-57%, medium level-34 % and low level-9%. The results obtained allow us to recommend the technology of 3D modeling in LigroGame as a method for developing cognitive activity and engineering thinking in older preschool children.

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