The Application of Augmented Reality in Education and Development of Students Cognitive Activity

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Abstract

The article analyzes the study of domestic and foreign scientists who consider augmented reality as an instrument of education. The authors present aspects of the study of AR technology in education, prospects of usage of virtual and augmented reality in the educational process; strategies for using AR-technologies in training. It has been established that the use of augmented reality in the educational process has a number of peculiarities and benefits, in particular, augmented reality is a highly interactive resource that causes emotional experiences; complete immersion in to the training process due to 3D visualization and elements of gamification; the possibility of a smooth transition from abstractions to real models; activation of research activity by means of collecting, comparing, analyzing and displaying experimental data. The separate services of using visual methods, in particular, Merge, VoyageAR, Quiver, 3dBear are analyzed. The authors separated the following services as: GoogleLens, LabCamera, SketchAr, Tinkercad among the 2D instruments. It is noted that the didactic material used in the training course is realistic models and images created using 3DSmax and Photoshop editors. The methods of using the instruments of augmented reality as an example of the projects Lego robotechnic (applications Just a line, Merge Cube Viewer, LabCamera, ARRuler, FaceRig) are given.

Keywords

AR-technologies; means of augmented reality; services of infographics and cooperation; means of interactive visualization; 3D and 2D instruments; cognitive activity

1. Introduction

One of the modern educational trends is the introduction of a STEM education model, which is aimed, in particular, to develop cognitive activity of students of all ages. The STEM model is implemented in accordance with the level of the students' knowledge and skills at primary, secondary and high schools, but generally it ensures execution of the following tasks as support and development of curiosity in children, demonstration of combination between science, technologies, engineering and everyday life.

For children of preschool and junior school age the STEM centers offer a spectrum of IT-clubs in robotics, animations, 3D modeling and basics of programming. That is why, the means of augmented reality are the most effective in these fields, because they make it possible to visualize complex abstract objects, devices schemes, technological processes, etc. Educational robotics is considered as an instrument of knowledge modeling, involving development of a model that can be verified in a physical environment.

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The usage of the means of augmented reality in educational process has a number of peculiarities and advantages, the main ones are: the results of experiments are more approximate to real life than when using classic digital tools of modeling; augmented reality is a high interactive resource that causes emotional experiences; high interactivity provides variety of the results of the executed tasks and satisfies the rates of individual training; full immersion in to the process of training due to 3D visualization and elements of gamification; activation of research activity by means of collecting, comparing and displaying experimental data [1].

Modern foreign authors investigate various aspects of AR technology application in education, in particular, the usage of AR applications in various educational areas (Billinghurst, M. [2]; Mehmet Kesimand Yasin Ozarslan [3]; Chen, P., Liu, X., Cheng, W., Huang, R. [4]); implementation of 3D technologies, virtual and augmented reality into the educational process of high school (Debopriyo Roy [5]); usage of augmented reality for e-learning (Dutta Kamalika [1]); introduction of AR-technologies to support STEM education (Ibáñezmarí.-Blanca. & Delgado-Kloosc [6]); AR mobile app development for primary school (Behrang Parhizkar; Waqas Khalid Obeidy; Shahan Ahmad Chowdhury; Zahra Mohana Gebril; MIke Ng Ah Ngan; Arash Habibi Lashkari [7]), Gustavo Salvador-Herranz, David Pyrez-Lupez, Mario Ortega, Emilio Soto, Mariano Alcasiz, Manuel Contero [8]).

The scientific works of domestic scientists also presented the following aspects of using AR-technologies in education: the usage of technology of augmented reality in a mobile-oriented training environment (Ye.Modlo, Yu.Yechkalo, S.Semerikov, V.Tkachuk [9]); creation of mobile application for visualization of educational material from natural disciplines using AR technology (Midak Lilia [10]); use of textbooks and manuals in the educational process, which contain specialized objects with augmented reality technology; educational games; modeling of objects and situations; applications for skills training (O. Chubukova, I. Ponomarenko [11, p. 23]).The main approaches to application of the technology of augmented reality into the educational process of higher educational establishments are defined by O.Karabin [12, p. 108]. Investigation of the augmented reality technology application the process of study of the disciplines of elementary and secondary schools is presented in the work of O. Oleksiuk [13].

2. Augmented Reality Tools for Working with Children

The method of augmented reality can be represented in the form of such a structure: means of interactive visibility (3D object models; interactive (games, colouring); 2D instruments (measurement of speed, time, size, etc. instruments for simulation); services of infographics and cooperation (drawing, construction of schemes in a virtual environment; binding models to a place, marker, coordinates).

The Merge was chosen as the main service of interactive visibility. The service engine uses a marker augmented reality, this marker is represented by a plastic three-dimensional cube, which, unlike plane markers, increases stability of displaying 3D models. The similar service is VoyageAR, which offers a finished database of lessons in natural disciplines. The paper cards with information on the topic of the lesson are used as a marker. The lessons in addition to models in augmented reality include interactive multimedia materials.

The Merge was chosen as the main service of interactive visibility. After creating the 3D models were downloaded in to the Merge service base. During classes, the MergeObjectViewer application was used, which allowed to design the 3D models created with help of other services in to augmented reality. The similar service is VoyageAR, which offers a finished database of lessons in natural disciplines.

The Quiver service - presents collections of interactive colouring on different topics, oriented to work with children of preschool and junior school age. Children draw traits, colour and features of a character or an object on the sheet of paper and simultaneously see as their character changes in virtual space.

The 3DBear service is an editor of augmented reality. The process of working with the service involves placing various 3D models over the image from the camera, it allows you to create a virtual scene for a model built from the Lego designer. The application Holo adds animated holograms of people, animals and characters over video or photo.

Among the 2D instruments we separate the following services: GoogleLens is an interactive camera that recognizes objects and presents information about them. The LabCamera – can measure the distance, size, plane and volume of objects taken to the camera using the data from the camera. It is used during classes to register results, during elements of games and competitions between the models created by students. To build infographics, we offer the SketchAr application, that allows drawing schemes in the virtual space not limited by the size of a phone screen, fix the received circuit in the photo from the camera.

The basis of the didactic component of the educational program with LEGO robotechnic was the usage of 3D materials and instructions created with the help of graphic editors.

For modeling of simpler objects, the Tinkercad online editor was selected. Unlike the 3dsMax, the Tinkercad is focused on teaching children the basics of 3D modeling. It is simpler, and it allows you to distribute 3D objects and provides access to the models created by the service participants. The operating interface of the editor contains blocks with various finished elements, geometric figures, parts of mechanisms, characters, electronic components. The models created in the Tinkercad were used mainly to demonstrate the principles of mechanisms operating, contained only abstract essential features of the object.

Another kind of didactic materials used in the course are realistic models and images created using 3dsMax and Photoshop editors. 3dsMax is a powerful 3D graphic editor that includes the entire spectrum of the necessary opportunities for building three-dimensional models, structure and simulation of physics, animation. The large numbers of models where used from free access bases, for example Thingiverse as one of the most convenient. The instructions prepared in this way is the most close to the fact that children should build from a real designer during class.

The models created in the 3dsMax were also used to represent the natural and artistic images at all stages of projects implementation. For example, in the Project "How Butterflies Live", the 3dsMax was used both for creation of real models of butterflies and caterpillars, on the basis of which children drew the wings of a butterfly and to present the life of these insects at the appropriate stage of this project.

3. Usage of Augmented Reality Tools for the Development of Children's Cognitive Activity on the Example of Lego Robotechnic Projects

In this study, we consider the children’s cognitive activity as productive activity aimed at the process of knowledge. Cognitive activity consists of the system of motives, knowledge, skills, abilities and personal qualities of a child directed at ensuring of the process of education, independence and execution of the set tasks.

In accordance with evaluation of the level of participants' cognitive activity in the course of Lego robotics we separate the following components: motivational, cognitive, active, reflexive; and the levels: high, medium, low.

The motivational component is determined by interest, positive attitude to the study of the subject; expressiveness and intensity of emotional manifestations associated with learning. The cognitive component is determined by the level of knowledge, possession of the relevant skills and abilities of the students.

The active component is manifested through working capacity, readiness of situational usage of acquired knowledge, independence in the process of performing tasks of various complexity. The reflexive component is determined by the level of initiativeness, self-control and self-organization during the lessons.

At each lesson of the Lego robotics course, the Stem teacher assessed the level of participants for each of the four components on a scale: 1 - low level, 2 - medium, 3 - high. Based on these data, the dynamics of changes in the components of cognitive activity of participants of junior and senior groups during the course was determined.

To determine the level of cognitive activity of each child the sum of points for each component was used, respectively, the score of 4-6 corresponds to a low level, 7-9 medium, 10-12 high. These data allowed us to determine the percentage distribution of participants between the levels of cognitive activity in all groups at each stage of the experiment.

We developed the program with LEGO robotechnic for children 5-7 years to determine effectiveness of influence of the means of augmented reality on development of the children’s cognitive activity. The basis of the course is a set of tasks LegoWeDo 2.0, whose educational goal consists of such educational purposes: development of creative thinking during creating existing models; carrying out systematic observations and measurements; logical thinking and programming of the given model behaviour; reproduction of a play-act scenarios.

Let is consider the methods of instruments of augmented reality usage as the example of the project of Lego robotechnic "Pendular Car". The purpose of this project is to expand presentation of students about mechanical energy and movement. During classes, the students should investigate the phenomenon of oscillatory movement, to build a model that uses a oscillatory movement of a pendulum for moving in space.

At the initial stage of the project for frontal work, we use the Model of anchor mechanism collected from the Mindstorms set. With the help of the application Justaline and the photo of the model, children note initial information about the pendulum, schematically determine the purpose of the project realisation. In further work, we use the finished models from the section "Mechanisms" of the MergeEdu library. All the models are displayed using the application Object-Viewer and the MergeCube marker.

The next stage of the project is to build the basic mechanism from the designer, research of its work and testing. As a manual, we use the models of the parts of a pendulum platform created in the 3dsMax in the form of complicates contributes to development of dimensional thinking.

During the stage, when each child has a working model of the mechanism, we measure the period of oscillation of the pendulum and time with the LabCamera application. The Justaline application allows each student to draw schematically these results on the photo of the working model.

The latest stage of the project is improvement of models and conducting competitions between the models created by classmates. The schematic models created in Tinkercard are not instructions, but they show the principle that can be done to improve the pendulum platform.

During the competition, we use the ARRuler application that measures the way passed by the childrens' pendulum platforms, saves the obtaining results with the photo of the models.

Another example of the project, which involves application of augmented reality, is the project "Fantastic Animals". Implementation of the project is realized to consolidate the studied mechanisms of mechanical transmission of energy and movement.

At the initial stage of the project realisation, children randomly receive cards with a QR code that contain references to the 3D models of fantastic animals, and brief information about them.

During the presentation of stories and fairy tales about fantastic animals one can use the GoogleLens application that allows children to find quickly information about the objects presented in the context of fairy tales. We offer to make dramatization using the FaceRig service. At this stage, also we use the Qiver application, the library of which contains the characters that are suitable for the topic of the project.

At the stage of building models, we offer children the elements of the images of fantastic animals presented in the Thingverse library. Now children also have access to 3D instructions of several previously created mechs.

At the final stage, using the Holo application allows you to add the drawings and characters necessary for further dramatisation on the video. As a result, we get a video presentation of a fairy tale with a frame-by-frame animation, where the model of the Lego mech is used, the voicework is done by children, the scene are the objects added by the means of augmented reality.

Now we propose to consider the project of natural orientation "As Butterflies Live". The purpose of the project is to familiarize children with a variety of butterflies and their life cycle. Creating the 3D collage "Life Cycle of a Butterfly" .

After presenting the topic of the project, we use the Sketch AR application that contains the images of various variants of patterns of wings and projects them on paper, it simplifies the process of drawing.

At the next stage children can build the map of knowledge that reflects reaction of the butterfly model on information from the sensors Wedo 2.0 with the help of the Sketch AR application. At the stage of constructing a butterfly mechanism from a designer, we use the instructions created by the MergeEdu. As a result, children receive models of butterflies with the unique drawing of wings that react to light and their position in space. To expand the game capabilities with these models, we suggest creating environment, with the help of the Holo or 3dBear application. The application allows children to create a scene for a plot game with the Lego model butterfly by means of placing them in augmented reality.

The video recording of this game is an intermediate result of the project execution by children. Then teacher scans these models using the Qlone application and get the 3D models for creating a collage on the final stage of the progect.

The next stage of the project involves children study the life cycle of the butterfly(egg, pupa and caterpillar) with the help of schemes, representing in the Voyage AR application. One can construct this scheme using the Sketch AR application.

At the stage, the constructions of the model of a caterpillar, except instructions in augmented reality, one can use the LabCamera application. It allows you to measure the correct operation of the caterpillar mechanism. Then children should represent environment where a caterpillar lives, using the Holo or 3dBear application.

At the final stage, children execute modeling of an egg and a pupa independently. After combination of the Qlone scanned models in the 3dsMax, we get a 3D collage "Life Cycle of a Butterfly" that contains the models created by children.

4. The Results of the Experiment

The experiment was carried out in three stages. At the first stage on the basis of STEM laboratory "Academy of Professions of the Future" a control and experimental groups were formed, each of which in turn was divided into junior, which included 24 children of 4-6 years old, and senior - 20 children of 6-8 years old.

The initial review showed approximately the same levels of cognitive activity of participants in the control and experimental groups. The second stage – conducting an educational experiment involved the use of experimental methods of using augmented reality tools, collecting empirical data during 9 classes and determining the impact of augmented reality at the level of components of participants' cognitive activity.

The third stage – control, was aimed at comparing the levels of cognitive activity of the experimental and control groups to determine changes in the distribution of participants between levels of cognitive activity at the beginning of the experiment and after classes using augmented reality tools, analysis and explanation of the results.

As can be seen from the diagrams, the greatest positive shifts happened in the older groups in accordance with the reflexive and motivational components, and in the younger ones according to the reflective and active components. The usage of the means of augmented reality contributed to a more captivated attitude to the learning process in experimental groups, and it is manifested in more uniform indicators on the diagram of their cognitive activity. In control groups there is a sharp change of indicators associated with selectiveness of the participants' interests depending on the topic of classes.

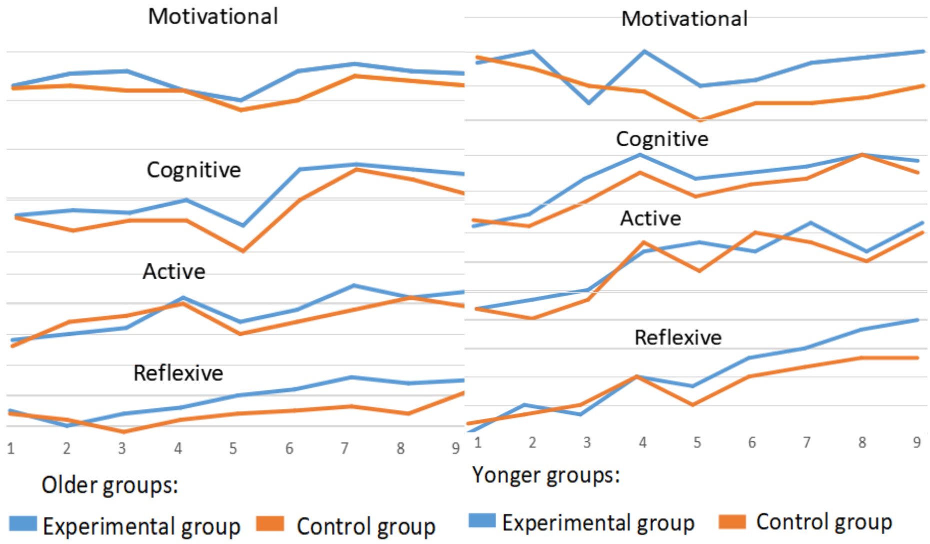

Figure 1: Dynamics of changes of the components of cognitive activity of the participants of older and yonger groups during 9 classes of the course

Determination of cognitive activity components formation in the participants of the of Lego robotics course showed that the levels of the motivational component formation in the experimental and control groups have changed as follows: in the older experimental group, the number of participants with high-level increased from 45% to 60%, and in the younger – from 21% to 33%. In control groups these indicators are smaller, in particular, the indices in the older group increased from 45% to 50%, and the indices in the younger group did not change. At the same time, a low level decreased significantly: in the older experimental group – from 15% to 5%, and in the younger one – from 46% to 25%. In the older control group – from 20% to 10%, in the younger – from 25% to 13%.

According to the cognitive component, the difference between the participants of the control and experimental groups is not so large, in particular, the number of participants with a high level in the old experimental group increased from 20% to 60%, while in the control – from 15% to 45%. In younger groups, the difference is slightly larger, in the experimental group, the percentage of children with a high level increased from 4% to 38%, and in control – from 8% to 29%. As for a low level, it significantly decreased both in older groups: from 50% to 10% − in experimental and from 50% to 35% in the control. It is due to the fact that the material and requirements for experimental and control groups were the same, and the usage of augmented reality contributed to the best general atmosphere during classes and affected this component indirectly.

According to the active component, one can see the uniform development of the levels of participants both control and experimental groups. The difference between the experimental and control group was 5%, the number of participants with a high level of active component increased from 25% to 70% in the experimental group and from 20% to 60% in the control group. In younger groups, this index is slightly more, it increased from 17% to 63% in the experimental group, and from 25% to 50% in the control. This difference is due to the fact that for most participants, the activity of this type was new, but classes on the stage of the forming experiment were oriented precisely on children of this age and allowed them to easily master the previously unknown material.

As for the reflexive component, it should be noted that in the older group the number of children with a high level increased from 15% to 45%, with average decreased from 45% to 35%, and with low decreased from 40% to 20% due to a large number of participants who that increased its level from low to average and from average to high. In the control group, the high-level indicator has increased from 20% to 35%, the average – from 30% to 35%, and low decreased from 50% to 30%. In the younger experimental group, the percentage of participants with high level increased from 8% to 13%, while in the control is from 4% to 8%. The difference in the number of participants with average level is greater: in the experimental group, this index increased from 42% to 58%, and in the control group –from 50% to 54%. As for a low level, it has changed in the experimental group from 50% to 29%, and in the control - from 46% to 38%. Such results are explained by the fact that the means of augmented reality require a permanent comprehension of the participant in the process of working with them, in particular, they require more control during collection of the models.

The results of the forming stage of the experiment showed that the usage of augmented reality effectively affects the development of the children's cognitive activity, increases the level of motivation, self-control and interest learning process during classes from Lego robotics. It is especially noticeable in work with young children, where the means of augmented reality kept children's interest throughout the course, while the control group has noticeably lost interest from 4 classes. The influence of the means of augmented reality on the cognitive and active components of cognitive activity was found to be smaller, there they showed themselves at the level of other digital technologies. On the other hand, work with the instruments of augmented reality requires to pay more attention to self-control and verifying the collected models, such activities indirectly contributed to development of cognitive and active components, especially in older children. In general, children are made ready to work with such instruments, but they require more support from the teacher for understanding and usage the information presented in the format of augmented reality.

5. Conlusions

The scientific analysis of the problem of usage augmented reality as the means of students' cognitive activity development made it possible to conclude that the problem of application of digital technologies has become the leading in the pedagogical theory and practical activity of domestic educational institutions in conditions of informatization of the educational process.

The study of the current state of usage of augmented reality in to the educational process of educational institutions has confirmed the relevance and expediency of this research problem and allowed to develop the program with the Lego robotics for children 5-7 years, based on the set of tasks WeDo 2.0. It gave the possibility to determine the effectiveness of influence of the means of augmented reality on development of the children's cognitive activity.

In order to determine the effects of augmented reality on the participants' cognitive activity, we proposed comprehensive methods that predicts the usage of sociological research methods, in particular, experimental conversation, interview, questioning; methods of empirical level – pedagogical observation; methods of summary and processing of experimental research results – a graphical method, tables, ranking, grouping. The participants of research were divided into a control and experimental groups, each of which in its turn was divided into a younger, which included 12 children 4-6 years, and the older – 10 children 6-8 years.

Development of technologies of augmented reality allows us to remove means of visibility on the new level of interactivity. For a teacher, the usage of augmented reality has many advantages, in particular, and those that are presented in the results of our study. However, it is worth to indicate the disadvantages of the technology of augmented reality, typical for all digital means of training. In the process of creating own didactic materials, the teacher faces the need to work with 3D graphics editors that require individual training and related technical competencies.

We consider development of new applications with augmented reality, which is the next step in development of digital visibility as the prospects for further research.

Digital materials to textbooks must contain both means of augmented reality and interactive elements where the usage of augmented reality is not expedient, for example, video recordings, text tasks, etc. Only development of such didactic materials will be able to provide modernity of the domestic system of education.

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