AR and VR as gamification of cognitive tasks

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Abstract. The paper presents a comparative analysis of the functionality of mobile applications of the augmented reality Da Vinci Machines AR, Electricity AR, Bridges AR, Geometry, the collection of VR models VictoryVR Science Curriculum and the digital collection Mozaik. The possibility of using these tools for educational purposes, in particular, for creating cognitive tasks for students during the study of subjects in the natural and mathematical cycle, is explored. The indicated shortcomings are stated, didactic requirements for such educational activities are formulated. Among others, attention is focused on the following indicators: hardware, usability, variability of model parameters, interactivity, interdisciplinary use, and the ability to activate certain cognitive actions of students, degree/form of gamification. The educational potential of using interactive models and video for both group and individual work with students is analyzed. Examples of methodical developments are given.

Keywords: learning environment, gamification, virtual reality, augmented reality, synthetic learning environment.

1. Introduction

Converting technologies of the NBIC (nano-, bio-, info- and cognitive) create a new environment for human life and promote to the fundamentally new instruments of the techno-evolutionary process. Naturally, scientists associate their hopes with the creation of the concept of combining the humanistic and technological components of the educational process, creating a positive integrated reality provided convergence of physical and virtual learning environments. We believe, the positive potential of the information and education environment saturated with digital technologies can be manifested primarily in the growth of cognitive activity of every learning subject. If students learn the information images of real-life phenomena and processes, by experimenting with different digital instruments and technologies (simulation, computer simulation, complemented reality, etc.), this will provide creative activity in the integrated (real and virtual) learning environment. The trends of modern corporate learning (virtual and augmented reality, artificial intelligence, including the use of chat bots, knowledge bases, video content creation, micro curriculum and mobile

learning) affect the evolution of tools, forms and methods of teaching in general education [1].

The modern trends of corporate learning are virtual (VR) and augmented (AR) reality, artificial intelligence, use of chat bots, knowledge bases, video content creation, micro curriculum and mobile learning. They influence the evolution of tools, forms and methods of teaching in general education.

The **purpose** of the article is to analyze the use of AV and VR in school education.

2. Related Work

Gamification as a direction of research in education has appeared relatively recently, it is based "on the intersection" of psychology, behavioral economics, management, and game design. To date, the most cited publications are the works of M. Barber, J. McGonigel, D. Clark, Lee Sheldon, K. Verbach. According to Kevin Verbach, "Gamification is use of gaming elements and game design techniques in non-gaming contexts". Among the various forms of gamification (competition, game without winner and aesthetics), we have focused on creating a general game impression that promotes emotional engagement, the ability to make the task more understandable, to clarify the nature and effectiveness of the phenomenon in action, to enhance the visualization of results, to strengthen the vector of mental development. Our point is to use AV/VR for this.

In psychological pedagogical literature, we increasingly encounter research on the influence of the games effect on motivation in education. We agree that the use of games in education is an actual trend. An engaging game makes a sense of joy and fun. So the use of games can increase the interest in learning. However, gamification changes behavior psychologically. Students can focus on receiving awards, but not on the training itself. By exploring some of the aspects of gaming, we propose to clearly distinguish between "learning in the form of games" (or game-based learning) and "gaming technology in learning."

Features of Game-Based Learning we consider: awards, badges, scoring points, ratings, team work. There are quite a few experiments in which learning is presented as a game. Thus, Sheldon Lee [4] presented the experience of creating a course in an educational institution as a multiplayer game that became very successful. And the conclusion about the success was made on the basis of studying the results of student learning and their interest.

The main weapon of Game-Based Learning is a simulation that can be either digital or not. In manufacturing and business, the use of appropriate software and hardware that supports this form of learning is not new, it is developing dynamically and has not yet reached the peak of popularity. Walmart (Customer Service Providers), KFC (Cooking), Schlumberger (Operator Performance in Emergency Situations), BMW (Interactive Guide to Reveal and Avoid Troubleshootings) is a small part of the good practice of using VR in vocational education. However, in our opinion, although the virtual reality creates the effect of full immersion, the

augmented reality will find more use in schoolchildren education. The technology of augmented reality can be considered more democratic, since the user has enough to have a smartphone. In contrast, one needs special tools for viewing and managing in the VR course: helmet or virtual reality glasses, and a variety of manipulators that capture the user's hand and gestures and give you more control over the environment.

The use of the game form is a broad field for pedagogical discussions. The subject of our study is the use of gaming techniques, tools and applications with a clearly defined purpose of learning and the corresponding pedagogical result, that is, they are characterized by educational and cognitive orientation. Creation of educational situations, acting as a means of encouragement, encouraging students to cognitive activity are in focus of our scientific interests.

In modern philosophy, the phenomenon of virtual reality is investigated in a wide range, but most of the concepts relate to the assessment of the impact of virtualization and the human nature. The development of information technology expands the possibilities of visualization. The use of images as a means of communication is characterized by maximum bandwidth, high information capacity. G. Reinhold speaks about virtual reality as a "new world", a new parallel reality. Virtual reality, in his opinion, can be regarded as a magic window that allows you to look into other worlds, the world of molecules or the world of our fantasies [5]. Investigation of the phenomenon of virtual reality has a direct connection with the development of information technology, philosophical comprehension of which is carried out in the works of D. Bell, M. Kastesels, N. Kirilova, M. Maklyuena, E. Toffler and others. VR is considered by scientists from the standpoint of engineering psychology of human-machine interfaces, and also became the subject of anthropological and social studies.

Not all 3D visualization systems can be classified as VR. The main features of the following [6]: the image is stereoscopic; the image is coordinated with the coordinates of the visual sensors; the system is equipped with a bidirectional interface (input - coordinates of healthy sensors, output - image); a short time that does not exceed 1/16 second to refresh the image in response to the change of coordinates of the sensors. The most advanced systems of virtual reality allow you to realize the illusion of "full immersion" in the virtual environment.

Different sources can distinguish types of VR systems, the delimitation of which lies in the plane of the methods and modes of their interaction with the user.

1. "*Window to the World*" uses modern computer monitors to display the visual part of the cyberspace. For example, the phone can be used to view travel with the Google Cardboard application, or use the 2D "magic window" mode on the tablet.

2. *Videocameras* uses a camcorder, the user's silhouette is superimposed on a two-dimensional image created by the computer, resulting in a user looking at the screen and seeing his/her silhouette, his/her virtual body in the cyberspace that interacts with the virtual world.

3. *Diving systems* creates a sense of presence.

4. Systems of *remote presence* uses connections of remote sensors, located on any object in the real world, with the operator.

Nowadays, a fundamentally new type of tools is used as well: Mixed reality (MR) that is a combination of remote presence systems and virtual reality-based systems.

The image is generated according to the information extracted by the sensors of the remote presence systems, and allows seeing the interaction of real and virtual objects. A person can evaluate as there is a point of touch of real and virtual objects in objects located relative to each other [7].

VR completely replaces the real world and a human sees a picture, a painted, simplified environment. According to data known, abuse of VR faces a problem called cognitive overload or information overload at a cognitive level. In other words, the number of needed operations exceeds the brain's capacity. This term describes the difficulty of understanding the problem and making decisions, which is the reason for the excess information [8]. In response to cognitive overload, cognitive distortions may occur, for example, loss of objectivity in selective perception: a human chooses information that is consistent with their expectations and ignores everything else.

We share the opinion that the augmented reality is precisely the technology that can free up the brain, free up a part of the cognitive effort and help to optimize their use. AR is a combination of the real world and the layering of virtual images on it, a partial replacement of the real world. In essence, it is a hint or hologram that is superimposed on the real world. Usage of AR gives a sense of the real location and interaction of objects with the world. In our opinion, this is a positive difference between the augmented reality of the VR and the MR. Augmented reality introduces only some artificial elements in the field of perception in order to supplement the information about the environment and improve the perception of information.

Despite the hype, intensive PR, considerable interest in these modern technologies, there is an urgent need to "get back" to the basics of learning and accounting results of pedagogical research in the field of cognitive processes. Successful implementation of VR/AR technologies as learning tools has certain pedagogical backgrounds, including the creation of technically complex content and its methodological support.

The authors reviewed the problems of introducing a synthetic learning environment in the practice of education. The modern views on the essence of the learning environment and its new forms based on information and communication technologies are analyzed. Particular attention is paid to a range of issues that are united in the English-language publications as a "synthetic environment", which is considered in two aspects: artificial environment and synthetic one as formed due to the synthesis of the real physical world and the results of simulation and modeling. There are considered issues of trends in usage of game-based learning and modeling as cognitive technologies [9]. The research uses the analysis' results of the historical aspect of the formation of computer modeling as one of the perspective directions of the educational process' development. The description of the peculiarities of the organization of students work using a computer modeling system, individual and group work is given, the aspect of motivation of students to study is considered [10].

According to the report "Virtual reality and its potential for Europe" [11], education is one of the priority directions of VR technologies application. Our research is aimed at creating a pedagogically balanced justification of methodological systems that use VR/AR technologies to model cognitive tasks, in particular as an element of their gamification.

3. Research Methodology

We used the theoretical findings of scientists regarding informatization of education (V. Bykov, R. Gurevich, M. Zhaldak, A. Gurzhiy, etc.) and scientific and education principles of formation and use of information learning environments (V. Bykov, Yu. Zhuk, V. Olijnyk, Ye. Polat, etc.). Also, the comparative methods used to study the phenomenon of virtual reality in the concepts of M. McLuhan, M. Castells, A. Toffler and H. Rheingold.

Several theoretical methods are used in the study: analysis of research problems in scientific publications; study of the experience of using VR and AR in the learning process, methods of comparative analysis, methods of mathematical statistics for processing quantitative characteristics of phenomena under research.

The theoretical basis of pedagogical research is the system-activity approach in education (L.S. Vygodsky, P. Ya. Halperin, V.V. Davydov, A.N. Leontiev, D.B. Elkonin et al.). The results of research and practical experience of Ukrainian and foreign teachers and researchers in the field of computer-based training technologies prove the adequacy of the chosen research methods and the relevance of the problem.

4. Results and Discussion

There is a narrow boundary between VR, AR and MR concepts (Fig. 1).

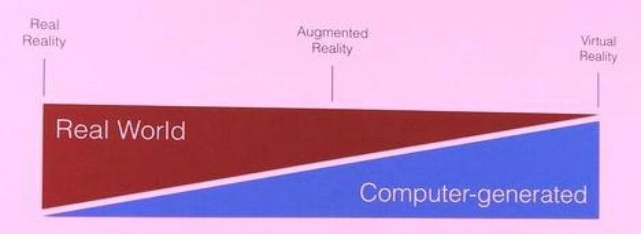

Fig. 1. Immersive computing spectrum [12].

Information and communication technologies generate a significant number of realities. At the Google I/O 2018 in Mountain View, the head of the AR and VR division of Google Clay, Bavor said that the VR/MR/AR/RR are not distinct and clearly defined. These are "convenient shortcuts for different points of the spectrum".

We have carried out a comparative analysis of functional capabilities, hardware requirements, educational applications of mobile applications of the augmented reality (Table 1).

The most popular of them are as follows.

The Brain AR App (https://www.harmony.co.uk/project/the-brain-in-3d/) contains mono-object models. It allows to study the human head, from the skin, muscles and skull to the inner regions of the brain. The appearance is recommended to be considered in AR mode, the internal structure of the brain can be studied in two modes of VR and AR as well. The program has an intuitive interface, but its use

involves explaining from the teacher. There is no adaptation in Ukrainian. The student remains an observer.

Geometry - Augmented Reality (https://itunes.apple.com/us/app/geometry-augmented-reality/id1309016689?mt=8) creates opportunities for active student action. The set of models is small (dot, straight line, triangle, quadrilateral), but the

Table 1. Comparison of mobile applications for education using AR and VR

Software	Equipment	Payment	Subjects	Ukraine language	Loading
mozaBook, mozaWeb	Tablet, VR-glasses	Paid, free+ Demo	all	yes	App Store Google Play Microsoft Store
Star Walk, Star Walk2	Smartphone, tablet,VR-glasses	Paid, free& advertising	Astronomy, life sciences	no	App Store Google Play Microsoft Store Aamazon
The Brain AR App	VR-glasses optional	free	Biology (human anatomy)	no	App Store Google Play
Google Expeditions	VR-glasses	free	Geography	yes	App Store Google Play
Human body (male) educational VR 3D	Smartphone, VR-glasses optional	free	Biology (human anatomy)	no	Google Play
GeoGebra Augmented Reality	Smartphone, tablet	free	Math	yes	App Store
Da Vinci Machines AR	Smartphone, tablet	free	Physics	no	App Store Google Play
Electricity AR	Smartphone, tablet	free	Physics	no	App Store Google Play
Bridges AR	Smartphone, tablet	free	Math	no	App Store Google Play
Geometry - Augmented Reality	Smartphone, tablet	free	Math	no	App Store Google Play
Geometry AR	Smartphone, tablet	paid	Math	no	App Store Google Play
VictoryVR Science Curriculum	Smartphone, tablet	free		no	App Store Google Play

student creates them independently by moving the markers in the real world and analyzing the result in the augmented world on the screen. The application is designed for initial assimilation by geometric shapes. Gaming equipment is expedient.

A tool for viewing and exploring geometric shapes using AR technology Geometry AR (https://itunes.apple.com/us/app/geometry-ar/id1329101716?mt=8). This is an application with a similar previous name, but with another functionality. Children can view flat and spatial figures, actually walking the picture to study shapes on all sides. Students use a slider or arrow buttons to move around the list of more than 25 figures studied in the course of geometry of the secondary and high school, as well as some algebraic curves (torch, ellipse, parabola, and hyperbole). The program contains reference materials with the possibility of audio text.

The Geographies' Augmented Reality app gives extraordinary opportunities for modeling and analyzing 3D objects, including surfaces created by rotating function graphs around the x-axis (Fig.2). It suit for classes with in-depth study of mathematics (https://itunes.apple.com/us/app/geogebra-augmented-reality/id1276964610).

This is an example of algorithmic models (demonstration of the implementation of a given algorithm) with the ability to make changes to the parameters. Depending on the choice of a real object application can be poly-project.

The collection of *mozaBook* models provides the opportunity to see physical processes, the structure of a chemical element or human body, historical exhibits, or a certain part of the world in three-dimensional form, and to listen to this information in different languages. With the help of smartphones, students can virtually explore these models, including simulation and gaming. The greatest benefit of this program is the creation of a teacher training course developed by a series of webinars (https://edpro.com.ua/webinars). There is opportunity to improve the visualization of the textbooks content that has proven themselves and have long been used (Fig. 3).

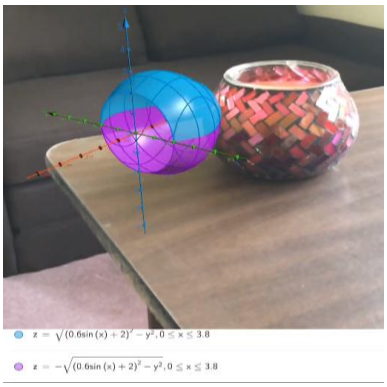

Fig.2. Modeling the surface of the candlestick by rotation of the sinusoid at the interval [0; 3.8] around the abscissa.

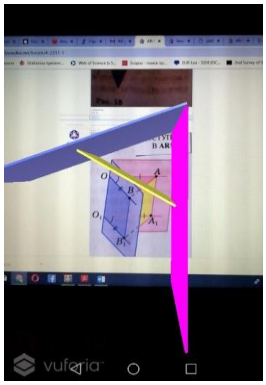

Fig.3. Illustration of a picture on a smartphone for the 10th grade class geometry tutorial for grades 10-11 (authors: L.S. Atanasyan, and others) using a mobile application.

5 Concluding Remarks and Future Work

An analysis of the existing trends in the study of the phenomenon of virtualization of reality (philosophy, cultural studies, sociology, psychology, political science, economics, natural sciences, technology, engineering) suggests that the place occupied by him in the socio-cultural space is quite substantial, and that over time, it will only grow.

The educational potential of the use of interactive models and video available through mobile applications is analyzed. The Brain AR App, GeoGebra Augmented Reality, Human body (male) educational VR 3D, Google Expeditions, Star Walk, Star Walk2, Da Vinci Machines AR, Electricity AR, Bridges AR, AR-Geometry, GeometryAR collection of VR-models of VictoryVR Science Curriculum and Mozaik digital collection. The overall game experience with the use of VR / AR technologies promotes the emotional involvement of students, promotes the availability of educational material, improves the visualization of the results of the analysis of individual characteristics of the study subject, activates mental development.

We prefer to use the effects of complemented reality as more accessible and less traumatic for the psyche of a young person.

The task is not to entertain the student, but to find new means, provide modern tools of activity - visual means of complementary reality technology, create educational situations that act as a means of motivation, stimulate students to cognitive activity, prepare students for life and work in the high-tech information society. Thanks to improving the visibility of the educational material and its interactivity, it is possible to conduct previously unreachable practical work.

The analysis of the programs focuses on the following indicators: hardware, usability, variability of model parameters, interactivity, interdisciplinarity, the ability to activate certain cognitive actions of students, the degree of gaming.

Problems that require further research in this area: increasing the success of learning, the pace of learning the material, the undeniable expansion of visual capabilities, and the development of educational skills.

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