Digitalization Of Education: The Use Of Virtual Laboratories As A New Stage In Improving The Educational Process

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Keywords: virtual laboratory, digitalization of schools, digital generation, modernization of education, additional reality, interactivity.

Abstract: The socialization of the modern generation is actively carried out within the framework of virtual reality due to large-scale digitalization. Research by foreign and domestic scientists shows that the thinking of children of the digital generation has undergone changes. Students who actively use information and communication technologies have a higher level of erudition, creativity, psychological flexibility, independence, the pace of orientation in the information space, multitasking, perception of non–verbal images. As a result, it is important to build the learning process using ICT. One of the most innovative, interactive and multifunctional ways to digitalize learning is virtual laboratories, which allow you to simulate objects and processes, organize access in virtual reality to laboratory equipment, chemical and biological components, specialized facilities and other inaccessible factors. This approach is able to take the traditional school to a new level that meets the needs of modern society and educate a generation with a high level of information culture.

1 INTRODUCTION

Digital technologies have become an essential part of every aspect of human activity, taking more and more important positions every day. As a result, modern people's lives are evolving and modernizing rapidly. The younger generation is socializing and adapting to the world under the influence of information and communication technologies (ICT). This influence is changing the way we perceive and think, and it cannot but affect the learning process. These changes have led to the development of an individualized educational process based on the use of new technologies.

Today, the educational resources available in most schools do not fully meet the demands of the field. One of the most innovative technologies in education is virtual and augmented reality (VR and AR), which can enhance the intensity and quality of learning.

Virtual space technologies open up a whole new world of possibilities for presenting material, focusing attention, and motivating students to learn.

"Virtual laboratory", according to E. O. Kozlovsky and G. M. Kravtsov, is a software environment for the study of objects that reflect in detail the properties in a certain field of activity.

S. A. Yampolskaya, V. P. Zhivoglyadov define virtual tools as software and hardware tools for research.

A.V. Trukhin reveals the content of the concept of "virtual laboratories" as a software and hardware complex aimed at the formation of practical skills.

A virtual laboratory is an environment that reproduces an interactive panel of an educational laboratory on the screen of a device, a source that provides the acquisition of practical knowledge, skills and abilities, allowing you to model objects,

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processes and phenomena that are not available for implementation in real space.

The concept of virtual laboratories is based on the creation of a 3D model of an object/space with which students interactively interact.

According to the purposes of using virtual reality, the following can be distinguished:

1. Interactive presentation and transmission of information, display by an object with a complex structure;
3. Creating virtual exercises;
4. Modeling of spatial objects.

Virtual laboratories allow you to conduct experiments, gain practical skills, explore the phenomena of the surrounding world, get acquainted with unique objects without endangering the health of the student.

This approach is able to take the traditional school to a new level that meets the needs of modern society.

One of the types of virtual laboratory is augmented reality, which integrates the necessary processes into the real world. Augmented reality is a technology that layers virtual images onto a picture of the real world. The distinctive features of the technology are interactivity and practice-oriented approach.

The use of augmented reality in traditional lessons will help to focus attention and interest students through an unusual, and sometimes even exciting, presentation of the material.

VR and AR technologies are especially important for understanding the disciplines of the natural science cycle, for demonstrating and understanding the nature of processes.

With the help of virtual laboratories, you can create an individual learning route for students with disabilities or suffering from self-isolation.

2 MATERIALS AND METHODS

Research in the field of the use of modern virtual technologies shows a high level of efficiency based on the development of spatial thinking and perception, as a result of which students better understand the subject being studied, and most importantly successfully apply knowledge when performing tasks of the VPR, OGE and USE and other types of control.

The rationality of using VR and AR technology in education is based on convenience, simplicity, and openness for almost every student. In addition to interactive and modern presentation of new material and practical work, virtual space technologies are able to test the acquired knowledge and distance learning.

The implementation of virtual and augmented reality technology in educational institutions defines the following tasks:

-to identify the theoretical and technological features of the construction of the educational process using virtual laboratories and to develop methodological and methodological materials for the implementation of the learning process;

-to educate and introduce students and the teaching community to VR and AR software;

-to modernize the teaching methods of disciplines, taking into account the further use of virtual technologies;

-to form the foundations of students' work in the classroom and in extracurricular activities using virtual and augmented reality technologies in various forms.

Modern ICT provides students with the opportunity to show their abilities and talents in full force, and the synthesis of several forms of information perception by the teacher enhances the learning effect, since the student receives information in several forms at once.

Virtual laboratories bring a number of advantages to the educational process.

1. Replacement of expensive equipment and materials

In many educational institutions, outdated equipment and reagents are used due to insufficient material resources, which distorts the results of experiments, and is also a potential threat to the lives of students and teachers. Software, unlike traditional hardware, compensates for its high cost with versatility, versatility and security.

2. The possibility of simulating processes that are fundamentally impossible within the laboratory.

3. An experiment in another time space.

4. Virtual laboratories are as safe as possible to use.

5. Conducting a series of experiments with different input parameters.

6. Experimental data is automatically entered into the results table, thus reducing the likelihood of possible errors and saving time.

7. The use of virtual space technologies in distance learning.

Virtual laboratories allow you to simulate processes that are impossible in a learning environment, to observe an experiment in another time space, while everything is carried out without threats to the health and life of both students and teachers.

The disadvantage of a virtual laboratory is the cost of software, but the costs are justified by functionality and security.

Access to VR and AR labs will allow students to conduct their own experiments, which may motivate them and interest them in studying the discipline.

The main advantages of using virtual space technologies are visualization and interactivity of learning, thanks to which it is possible to visually and easily demonstrate the material being studied, to reveal in more detail the essence of various processes.

VR and AR technologies are appropriate to use for:

1. work on experimental and scientific research;
2. simulations of the processes necessary for the assimilation of the set competencies if it is impossible to carry out (and/or) in the absence of the necessary materials;
3. Distance learning;
4. self-education;

Like any innovation, virtual laboratories need to be able to properly integrate into the educational process, so when selecting them, you should take into account:

1. Purpose, objectives and relevance
2. Divergence of problem solving
3. The variability of the difficulty level
4. The presence of meta-subjects
5. Visibility and interactivity
6. The ability to process information obtained during use
7. The forms and scope of the information offered.

Virtual laboratories are an important part of the high-quality educational process. The introduction of virtual space technologies into schools requires considerable resources: personal computers, smartphones and a high-speed network, web applications for learning. Virtual laboratories can be divided according to the following criteria:

1.By the method of treatment:

- on CD - ROM media;
- hosted on the web.

2. By the tool library used:

- simulation mathematical models;
- real laboratory equipment;
- industrial facilities.

3. By presentation methods:

- 2D graphics;
- 3D graphics;
- Animation (classical, computer, stop motion, motion capture);
- video.

4. According to the degree of limitation of the experiments carried out:

- a set of pre-programmed experiments;
-the use of mathematical models without limitation

5. According to the principle of operation:

- simulation of calculations;

These labs simulate operating systems in time using a PC. The essence of modeling is to create a model that surpasses an existing real object or process by a certain number of criteria. For example, an electronics program allows you to simulate electrical circuits and calculate the necessary characteristics.

- network applets;

Network applets are experimental devices of small virtual laboratories that are widely used in the scientific field. Its distinctive qualities are its small size and compatibility with all types of operating systems and software. As an example, a new generation virtual laboratory for IT professionals – EVE-NG 2018.

- standard virtual laboratory;

The Department of Theoretical and Applied Mechanics Virtual Technology is a library of projects that allow you to conduct experiments, learn online programming and visualization, and explore systems: mathematical, mechanical, physical, biological, etc.

- virtual reality laboratories (VRL);

The user acts as a part of the virtual world in a three-dimensional optical environment, which is a high-level interface, including real-time 3D modeling through sensory pathways. VRlab is one of the most popular virtual and augmented reality labs.

- Remote laboratories include real experiments conducted at a distance using information transmission media and a remote access point (control).

The remote laboratory "LiLa" ("Library of Labs") is a simulation environment with the possibility of a controlled online experiment.

The use of virtual environments allows students to better master the computer skills necessary for successful self–realization in the world of information and communication technologies.

Let's look at several affordable, functional, and multitasking virtual labs.

The VirtuLab resource is a collection of virtual experiences in various scientific fields. From the point of view of the technical device, this laboratory is a set of interactive Adobe Flash videos, some of which are designed in 3D graphics.

VirtuLab's collection of experiments is quite extensive and diverse. The laboratory's database contains four main blocks: biology, chemistry, physics, and ecology. The blocks include sections and topics of each discipline.

The multifunctional virtual laboratory PhET provides an opportunity to conduct experiments and research in the field of physics, chemistry, biology, geology, and has interactive mathematical tools.

There are also augmented reality (AR) applications. Modum Lab allows you to see a three-dimensional model of an organ, just point your smartphone camera at the illustration.

If we talk about virtual reality applications, the VR simulator at XReady Lab will allow you to penetrate into the tiniest world – the world of living cells. The peculiarity of this application is that it allows you to perform group tasks in different fields under the guidance of a teacher.

Traveling not only in space, but also in time is also available thanks to virtual reality, interactive resources such as Google Expeditions and "Voluminous History" will help in this.

Software development in the educational environment is one of the most important areas of programming today. The increasing popularity of educational software allows us to modernize the learning process, make teachers' work easier, and motivate students.

Students know better than anyone else what they need. That's why the Varwin Education training complex was created. It includes lessons on 3D modeling and programming. With Varwin Education, students can also form meta-subject connections. For example, a history teacher can use it to simulate a journey during the reign of different rulers of the Russian Empire. A chemistry teacher can simulate a dangerous chemical reaction for students in a computer science class.

Thus, the virtual laboratory provides additional opportunities for solving problems in various fields of study, allowing students to independently develop practical skills, explore the essence of phenomena and processes in greater depth, and motivating learning through interactivity and visualisation.

3 THE RESULTS OF THE STUDY

The information culture of students, based on knowledge and skills of working with information and communication technologies and other computerized learning tools, is formed in school computer science lessons.

The emergence of new ICTs creates a platform for the modernization of the traditional educational program regarding the content and means of implementation. New information technologies act not only as an object, but also as a means of learning, therefore it is promising and relevant to talk about the use of virtual laboratories.

When using virtual space technologies, a modern teacher may face the following problem: due to the lack of knowledge of the issue and the small number of proven virtual technologies, it is almost impossible to find methodological and didactic material.

There are several approaches to implementing virtual computer science teaching tools:

1. The first approach involves the creation of a virtual model that reflects on the material substitute of the actual object. Thus, the system visually complements the material substitute of a real object with virtual properties selected to perform the received task.

This approach is advisable to apply if it is impossible to carry out practical work in real conditions due to uniqueness or fragility, lack of the necessary element, or full-fledged equipment.

The most striking example of using this approach is the laboratory work on the assembly of a personal computer. As components of a computer (motherboard, processor, mainboard, graphics card, etc.), plain paper with special AR-reality markers printed on them is used to scan them by the system. A student looking through a device (tablet, smartphone, glasses, visor) sees virtual computer components in the workplace instead of markers. Manipulations are performed by moving augmented reality markers in accordance with the computer assembly rules.

The disadvantage of such laboratory work is the lack of practical development of skills for working with real PC elements, i.e. if each student has access to the necessary technical resources, the first approach is impractical.

Another significant disadvantage of using this approach is the lack of the physical shape of the object and its properties that could be felt in addition to vision, for example, the weight and texture of the object, but this disadvantage can be partially corrected by using substitute typical objects with a similar shape, texture or weight, including those printed on a 3D printer.

2. The second approach is based on the formation of a layer of virtual space on a real object, because students interact with real objects, but on which the augmented reality system has imposed an information layer. An example is laboratory work on the study of the components of a hard disk. A virtual layer is layered on a real hard drive, and the system displays a virtual equivalent, and students see the organization and structure of the disk with sectors and clusters.

In this case, the system "complements" the real object with the necessary information. This can be either a block diagram of the object, instructions for use, or various "layers", for example, the allocation of various functional areas of the microchip located in this chip, or the indication of the names of the elements of the motherboard.

3. The third approach is a mixed one. The above approaches can be combined to solve a certain type of problem.

For example, when teaching PC architecture in primary school, objects symbolizing computer components for recognition by the augmented reality system must be placed in the real case of the computer system unit in which the motherboard is installed. After that, by "placing" one or another replacement object on the motherboard, the corresponding virtual object is moved to the right place using an augmented reality system.

This exercise will allow you to avoid breakage of fragile computer components, select any configuration without unnecessary costs and minimize "routine" actions, which, as a rule, take a lot of time and effort, distracting from the formation of necessary knowledge and skills (for example, installing a cooling system on the processor).

All approaches are specialized in a certain range of tasks. It is worth noting that the second campaign is difficult to implement due to the ambiguity of the positioning of objects.

The proposed approaches will improve the effectiveness of computer science education, the level of independent activity of students.

The teacher's activity in the preparation and use of augmented reality elements in a computer science lesson consists of a number of stages.

1. The placemark object is selected. For example, if the textbook does not contain an up–to-date picture or a task, then AR technology, when pointing at the smartphone camera tag, will replace outdated information with a new version.

Let's consider a specific example, in N. D. Ugrinovich's textbook "Computer Science and ICT" basic level, grade 10, there is a practical work "Browser setup", screenshots and description of which are outdated and display incorrect information about the browser interface. The label is an illustration, which is replaced by an up-to-date video with a detailed description of the setup process.

2. Creating an AR reality layer. An image or a series of photo cards, videos, text information, and hyperlinks to an external resource are usually used as an AR layer.

The teacher saves all the tags used and sends them to his "channel".

Students have access to prepared content, in order to start interacting, students need to:

- install the HP Reveal program;
- connect to the teacher's channel;
- scan the labels.

These tags will be automatically saved in the catalogs of individual disciplines, and the student can return to work with AR-reality at any time.

The introduction of virtual laboratories into the educational process entails the implementation of certain tasks. Special attention should be paid to the variety of forms of content when implementing VR and AR technologies, so that all forms of information perception should be included in the technology: text, images, video, audio, 3D models, links to EOR.

4 DISCUSSION OF THE RESULTS

As practice shows, software and information and communication technologies in general are developing on a daily basis, so you need to take this factor into account to update educational content.

The advantage of augmented reality is also the fact that there is no need to replicate tags to update educational material, because the textbook with images is available to all students.

At the same time, working with innovative ICTs requires skills to work with such software, which becomes an additional task in the implementation of a school computer science course. This task is being implemented in parallel with the approved program. So, using the HP Reveal software tool, students perform direct learning tasks in a modern form and get acquainted with new technologies.

Virtual laboratories are a platform for discovering the creative potential of students. Students can become creators of augmented reality elements themselves. The creation of the basic element of an AR application takes place at the stage of solving problems in the screencast format. Students create their own labels in workbooks, which they can use to go to the screencast library.

Thanks to the use of virtual reality programs, the following urgent didactic tasks are solved:

1. The level of concentration increases;
2. The interest in the subject increases;
3. Skills and abilities are being developed, supported by knowledge of working with innovative software tools, in particular with virtual laboratories and augmented reality applications;
4. Motivation to learn computer technology;

5. Development of information perception skills in a sound, visual and tactile form at the same time.

For a teacher, the use of these technologies does not require much effort in terms of training. Creating tags and conducting a one-time instruction on working with a virtual software package among students allows you to use tags an unlimited number of times during the entire training period. Tag management is available anywhere for both teachers and students in their personal libraries.

From the point of view of economic value, the augmented reality tools necessary to modernize the educational process are free and available to every owner of a smartphone, which is now available, with few exceptions, to all schoolchildren. The economic feasibility is explained by the fact that the services used are free, and students have enough smartphones to start working with them.

Thus, virtual space technologies do not require large resources and perfectly fit in and improve the educational process, which means they can be recommended when teaching the school subject "Computer Science and ICT".

As such, there are few virtual laboratories for teaching purely computer science. Next, let's look at some of them and the tasks they should solve.

1. The system of virtual laboratories in computer science "Taskbook 2-6"

These educational materials are located in the Unified collection of digital educational resources School-collection. The task book includes 6 virtual laboratories:

1. Weighing,
2. Shifting,
3. Transfusions,
4. Crossings,
5. Traveling,
6. Black boxes.

Working with the task book involves both network and individual access to completing tasks with an increased level of complexity.

Reshinfo Virtual Laboratory – development is aimed at solving the following types of tasks:

- Number systems, general information
- Online translation of number systems
- Actions on numbers in the binary number system
- Actions on numbers in the octal number system
- Actions on numbers in the hexadecimal number system

Tasks are completed with a step-by-step solution, it is also possible to solve inverse problems, use early results, save the result in a document, share the final work and perform tasks in teams.

3. StarCluster is an open source cluster computing toolkit for Amazon Elastic Compute Cloud (EC2). StarCluster automates and simplifies the process of creating, configuring, and managing virtual machine clusters in the Amazon EC2 Cloud. StarCluster allows any user to easily create a cluster computing environment in a virtual space for distributed and parallel computing systems.

4. StarHPC provides a virtual machine image configured for parallel programming in both OpenMP and OpenMPI technologies. StarHPC can be used with Virtual Box, VMware Player, etc. to quickly get started with MPI and OpenMP programming.

As a result of the use of virtual technology in school, students will receive the following psychological and social skills:

- search and analysis of relevant and essential information;
- teamwork, the ability to correctly allocate time, tasks, responsibilities among the group members, based on the types of thinking and existing skills.

Professional skills:

- knowledge and understanding of the basics of innovative ICT;
- the ability to activate work with virtual space applications, assemble your virtual device.
- knowledge of the user interface and basic add-ons, skills in creating additional reality applications.

Thus, the use of VR and AR tools in the educational process guarantees visibility in the study of the material, safety and accessibility in use, attracting students to ICT in order to gain knowledge, and not only for entertainment, the possibility of conducting virtual classes, not only in a remote format, but also in another space, in a simulated reality.

According to research data, virtual and augmented reality technologies will be used in almost all fields of activity in the near future, therefore it is advisable to use virtual laboratories in various forms of educational and educational work so that the younger generation adapts to a dynamic and progressive life from school years.

5 CONCLUSIONS

The advent of advanced information and communication technologies, particularly virtual laboratories, has revolutionized the way we approach learning. These tools allow us to modernize our methods of presenting information, enriching the educational process with interactivity and effectiveness.

In the context of school education, virtual technologies serve as a gateway to mastering the art of navigating the complex world of multimedia and information streams. This skill is now essential for anyone seeking to navigate the information landscape with confidence. Therefore, it is crucial to incorporate computer technology into the curriculum.

The utilization of virtual reality (VR) and augmented reality (AR) laboratories in the realm of educational content development offers a multitude of advantages:

1. It fosters individualized learning experiences, catering to diverse learning styles.

2. It facilitates the creation of challenging and engaging problem-solving scenarios.

3. It enhances the visual appeal and interactivity of subjects under study.

4. It stimulates student engagement and active participation.

5. It enables the simulation of real-world problem-solving situations.

When conducting computer science classes using virtual laboratories and technical resources, the training will be most efficient if we consider the following factors:

1. The level of students' proficiency, which determines the nature of the tasks;

2. The tasks should not be overly complex or difficult to comprehend, allowing students to complete them within a reasonable timeframe;

3. A gradual increase in the difficulty level of tasks;

4. The implementation of problem-solving methods;

5. Diverse forms of work, contingent upon the type of class and activities;

6. Providing feedback;

7. Encouraging independent learning;

8. Developing metacognitive abilities, such as planning and evaluating outcomes;

9. Materials that cover a wide range of topics, catering to various cognitive processes;

10. Utilizing divergent problems that require multiple solutions or answers.

The virtual laboratory provides a plethora of opportunities for addressing challenges across a wide range of disciplines. It allows for the autonomous development of practical skills, deepens the comprehension of phenomena and processes, and fosters motivation through interactivity and visualisation.

In the educational context, virtual laboratories are indispensable for cultivating intellectually astute, well-rounded individuals with the capacity for creative and strategic thought.

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