Complex Information System Based on SMART Technologies

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Abstract—The structure of the complex information system is revealed, which includes: a component that assists the implementation of logical and meaningful relationships between mathematical, natural science and technological subject areas in the implementation of research and project activities. The concept of virtual reality and VR-technologies that allow optimizing the processes of foreign language teaching and learning is revealed. A complex information system is described as a form of creating virtual reality for learning foreign languages.

Keywords—information environment; engineering and technological education; networking; tablet computers; virtual reality; VR-technologies; VR-techniques; educational environment; foreign language teaching; foreign language learning

I. INTRODUCTION

Today, there are crucial changes in the sphere of technology, which have affected the field of education. The most important line of the development is “Smart education and e-learning”, the opportunities of which are extensively studied all over the world. The technological platform of this direction is information and cognitive technologies, which are the convergence of information and cognitive technologies [3].

In I. Robert’s works the substantial directions of fundamental and applied scientific research in the field of informatization of education in Russia and their demand in educational practice are proved and described [16-18]. The practical implementation of the results of fundamental scientific research is also presented there. In particular, modern education is carried out in the conditions of the phenomenon dubbed as an “personal identity on-line” – new ways of formation of the personality which exists not only in everyday life, but also in the virtual space, where one’s “Infosphere”, a complex system of human knowledge about the world and the system of knowledge about this man, as a set of all kinds of facts, associated with one, operate simultaneously. The process of cognition takes place within a new scientific paradigm – “data intensive science”. This paradigm claims that there is the priority of communication in the process of scientific research over generally accepted methodologies – theoretical and empirical [10, 19].

The basic key issue of human potential formation strategies for the future is the questions of the readiness of a school graduate for higher education - for effective teaching at a university, for scientific, research, and other creative, productive activities. Such readiness should be formed in the pre-university period, so that at the stage of higher education a person could already intensively develop his personal, professional and competence (scientific, research, development, etc.) potential and become involved in the processes of forming and developing the potentials of other people. Unfortunately, today the social institute of general education (secondary school) does not prepare massively for higher education and work at high educational, scientific and technological levels. We have to admit that the current educational situation is characterized by the weak interest of many students in general education schools, resulting in their low educational results, especially in relation to mathematical and natural sciences. The result is a weak awareness of the chosen engineering directions and obtaining higher professional education, which prevents school graduates from entering the cohort of people who provide and determine the future of the country's scientific, engineering, innovation and technological development [1]. The level of educational results of graduates of general educational organizations depends on the breadth of the outlook of pedagogical personnel, their depth of understanding of the world order in humanitarian, natural science, mathematical, technological aspects, readiness for creative pedagogical activity [2].

II. MATERIALS AND METHODS

In the most advanced (information-technologically enlightened) part of the pedagogical community of Russia
there is a demand for modern high-tech educational environment, including visualization and animation, tools for teaching in disciplines of natural science and mathematics and others.

In order to help teachers to initiate the cognitive activity of students, to arouse their interest and to involve new mental and psychological mechanisms of learning it is necessary to use the latest visualization technologies in the educational process (virtual and augmented reality, 3D modeling). The created educational content will be able to improve the educational results of students and develop their cognitive interests and abilities.

The term “Virtual reality, VR” was first introduced by a programmer Jaron Lanier in 1988 and was defined as “a combination of high-speed computers, advanced programming techniques, and interactive devices designed to make computer users feel they have stepped into another world, a world constructed of computer data” [11]. H. Rheingold in 1991 defined virtual reality as “an experience in which a person is surrounded by a three-dimensional computer-generated representation, and is able to move around in the virtual world and see it from different angles, to reach into it, grab it, and reshape it. Currently, virtual reality generally describes the technologies of head-mounted displays, boom-mounted displays and surround-screen projection-based displays. A head-mounted display consists of a pair of miniature displays positioned in goggles or in a helmet strapped to the user's head so that each eye sees one display. A boom-mounted display is like a head-mounted goggle display but is suspended from an articulated arm and is held to the viewer’s face with handles” [14]. Scott McGlashan and Tomas Axling defined virtual reality as “graphical two dimensional or three dimensional interface for interaction between the user and the computer that applies to computer-simulated environments that can simulate places in the real world, as well as in imaginary worlds” [21].

Today, specialists distinguish five main advantages of using VR-technologies in education:

- visualization: using of 3D-graphics creates a feeling of personal presence in the constructed world;
- safety: you can immerse the student in any place without the slightest threat to life;
- involvement: you can see the world, go on a trip to any country, etc.:
- focusing: the virtual world allows you to focus entirely on the learning content and not be distracted by external stimuli;
- a first-person view: one of the main features of virtual reality

The problem of visualization in teaching foreign languages has been relevant at all times. In recent years due to the desire of humankind living in the “society without borders”, familiarizing with the cultural heritage and spiritual values of the peoples of the world, knowledge of foreign languages as a tool of intercultural communication has become prestigious and in demand.

Virtual reality, as an artificial world (objects and subjects), is created with the help of technical devices. An integral part of VR is the impact on the main human senses: vision, hearing, smell, touch, and others. Unlike physical reality, which is the inner state of the individual, virtuality is a procedural interaction between the material and technical processes and the human psyche. The relevance of the use of VR technologies in education is also associated with an increase in the efficiency of this process, while it ensures convenience and accessibility for almost everyone. It should be noted that VR technologies are not only helmets and goggles designed for the perception of information by students, they also open great opportunities for the teacher.

In our project, the creation of virtual reality for the study of mathematics, mechanics and foreign languages is based on the “Complex Information System – CIS (“КИС” in Russian)”. This system is designed to organize a high-tech learning process and is a comprehensive solution based on innovative teaching methods using modern didactic materials.

Here is the list of the key characteristics of creation of virtual reality based on CIS:

- plausibility of events supports the learner’s sense of reality of what is happening;
- interactivity provides interaction with the environment;
- machine-generated environment is based on powerful hardware;
- creation of the effect of the presence of a clear visualization of a certain scenario involves both the brain and the user's body into the process, affecting the maximum possible number of senses.

The introduction of the CIS in the educational process will allow the achieving the following benefits:

- flexible and individual learning – learning that is adjusted to the level of the student in contrast to the standard process, the formation of individual learning paths;
- use of different content formats — use of IT and on-line and off-line learning, as opposed to standard textbooks.

The purpose of the creation of CIS is the creation of components and solutions of an integrated information technology system, combining organizational, methodological, software and technical solutions aimed at the effective functioning of the school (lyceum, gymnasium, etc.) using information technologies.

The implementation of the system will achieve the following short-term and long-term objectives:

- to develop new forms and improve the quality of educational services;
- to improve the quality of information services and their availability to users;
- to increase the impact of the use of information technologies in educational process;
- to reduce the total cost of ownership of IT resources by improving the manageability of resources.

CIS is open for the implementation of any applied tasks and technologies that can be in demand in the future by teachers and students. The solution architecture is flexible and provides for the universal use of subsystems and services, as well as increasing the volume of storage and functionality without changing the basic technologies (scaling).

Multimedia didactic environment CIS includes [1, 2, 3]:

- the content component that assists the implementation of logical and meaningful relationships between mathematical, natural science and technological subject areas in the implementation of research and project activities;
- the methodical component that prompts orientation for labor activity spheres of high-tech production, development of personal initiative, readiness for activity in the conditions of high-tech production, situations of uncertainty and instability;
- the communicative and organizational component that involves the implementation of the educational process on the basis of active, interactive teaching methods using SMART-technologies.

It should be noted that the capabilities of the CIS require the formation of interdisciplinary relationships between different subject areas, for example, between mathematics (mathematical models), mechanics, computer science and technology. Such issues as the balance of the fundamental and applied educational component in working with schoolchildren should be one of the key aspects of the formation of pre-university level educational programs. In our era of huge flows of information that schoolchildren have been confronted since childhood and many of which seem impossible for them to remember and assimilate (unlike schoolchildren of previous generations who have not encountered such a volume of information), modern students have a quite clearly articulated question: “Why do I need this knowledge? How can it be applied?” Moreover, this question is based on the needs of students to understand how it can be useful in their lives and why adults offer to do this. Wanting to find out the practical usefulness of certain knowledge and information obtained at school, schoolchildren often make persistent attempts to check whether adults themselves understand why they need to make efforts to manage such difficult knowledge.

In the industrial era, which in fact lasted for the whole XX century, fundamental science was the basis of technological development. Applied scientific knowledge used in practice was created on its basis. The approach to school education was also focused mainly on the formation of students' fundamental knowledge, not on their applied aspect. Such an approach in general education is still widely used at the present time: students are invited to study mathematics and the natural sciences, such as physics and chemistry, biology, etc., as the theoretical foundations of the sciences without their applied aspect.

But today, in the modern pedagogical community and in society as a whole, there is a growing understanding that in the early stages of schooling, it is necessary to form a conscious idea among schoolchildren that any information and theoretical knowledge of various sciences for innovative technological development of society (precisely for the future in which today's young people live) are important in the possibility of their practical application. But to form such an understanding among schoolchildren, it is necessary to change certain ideological “canons” that are traditional for the pedagogical community, making acquiring knowledge the meaning of education, and not the possibility of their practical application.

Isolated, highly specialized knowledge, included in separated academic subjects, outside the holistic interdisciplinary context, does not represent significant value for the practical development of society. They represent value only in synthesis with other knowledge, since only in this case they can be applicable to solving real problems (scientific, technical, economic, etc.) that never fit into the framework of only one science. [22].

Realizing that any specialized subject-specific knowledge is of real value only in the context of an integrated body of knowledge, it must be recognized that for everyone not only the university, but also the school teacher, it becomes important today to have a broad multi-subject vision in which the individual academic subject taught them integrated into the integral system view of the world. Thus, for pedagogical universities it becomes one of the priorities to form a progressive pedagogical worldview among teachers (present and future), which allows one:

- to be aware of the limitations of the content of their subject and acquaint the learner with the limits of subject knowledge, show the limits of its applicability in real life in the process of teaching;
- for each academic subject, to reveal ways to go beyond its narrow framework in wider, interdisciplinary knowledge, research and practice-realizing spheres and areas.

Forming a voluminous multi-subject, practice-oriented pedagogical vision in the community of pedagogical specialists of higher education and the general education system is quite a difficult task. Many generations of graduates of pedagogical universities have faced the narrow specialization of subject preparation. And these educational aspects became the problematization field of research and design for a number of researchers and designers of educational practices. For example, engaged in the study of scientific issues related to overcoming the subject-didactic narrow focus in the organization of general educational processes.

The need for students to master various scientific concepts, the formation of abilities and skills of operating and managing them are the most important conditions and the basic platform for the development of their thought processes. The concepts, supplemented by visual-figurative representations of a person, make up the content and structure of his thinking in the most diverse forms (productive, analytical, research, critical,
creative, design, artistic, and various other forms of thinking). The deep purposeful meaning of pedagogical activity - education - is the formation of productive human thinking, which leads to productive, creative actions, which results in everything new: any projects, solutions, scientific, cultural, social, economic and technological achievements, all innovations and much more. A person who does not think cannot consciously act, and therefore cannot create anything useful and cannot answer for anything. The students' thinking that is in the process of continuous development will push development and their interests, abilities, aspirations - this way the tangible outline and content of the students' personalities will be formed as a product of their education.

CIS can help a person choosing a pedagogical activity through his professional path, whether he is a physicist, mathematician or anyone else by professional specialization, develop students' thinking abilities, shape the content and the processes of their thinking, on which all conscious actions of people that are derivative products and consequences of the work of human thinking. That is why, in the educational and pedagogical context, the role of interdisciplinary concepts, enriching and developing thinking, directing it to diverse practical areas is so important. Concepts are the atoms and molecules of developed thinking, the components of its binding tissue and its volume. Of concepts consists of "mental substance" and the internal organizational structure of thinking. Interdisciplinary concepts - the most active elements of thinking - with the greatest energy, penetrating and controlling potential and influence on the external world [12].

The functionality of the CIS subsystems. The educational paradigm is changing from book-oriented to interactive learning, with support for digital content such as digital textbooks. The new educational environment is focused on the use of interactive features of modern technical solutions and cooperation with other teachers in the process of the creation of electronic educational resources. The scope of the solution in the educational process covers the entire range of the curriculum.

The integrated information technology system is located on the territory of the educational institution and consists of 5 subsystems listed below.

1. Subsystem of network interaction. The subsystem is a specialized hardware system designed to solve the following tasks:
   – to establish communication between the server, workstations and the big screen;
   – to provide access to the Internet;
   – to provide remote access to content;
   – to carry out joint work with documents.

2. Visualization subsystem. The subsystem is a specialized hardware and software system designed to solve the following tasks:
   – to display information on the big screen;
   – to display information in the workplace of all students;
   – to display information in the workplace when working in groups.

3. Control subsystem. The subsystem is a specialized hardware and software system designed to manage the schedule; content; courses; staff.

4. Information security subsystem. The subsystem is a specialized software package designed to provide comprehensive protection of the information system of personal data and all its components with the help of certified FSTEC software, hardware and software and ensure the safe interaction of the library's local area network with external networks.

5. Power subsystem. The subsystem is a specialized software package designed to provide comprehensive protection of the information system of personal data and all its components with the help of certified FSTEC software, hardware and software and ensure the safe interaction of the library's local area network with external networks.

The students workstations are equipped with tablet computers. The classroom is equipped with a projector and an interactive whiteboard. The teacher's desk is equipped with a local server.

Network infrastructure. To ensure mobility, the connection between students workstations, teacher's desk and the server is carried out with the help of Wi-Fi technology. The required guaranteed bandwidth between the user's end device and the server must be at least 10Mbit/s. To meet this requirement, a Wi-Fi endpoint designed to connect at least 25 users must be connected to the network core at the speed of at least 1Gbit/s and with the bandwidth of at least 300 Mbit/s. Therefore, cascading network equipment when connecting Wi-Fi endpoints is not allowed. The connection of subscriber devices to switch ports is carried out by means of horizontal cable wiring made by copper UTP cables of category not lower than 5e (signal cable type consisting of 4 twisted pairs).

To organize a segment without a wired LAN it is possible to use a set of equipment consisting of a wireless access point controller.

Tablet PC. Tablet computers are used to visualize educational materials and perform test tasks. This allows determining the degree of assimilation of educational material for a feasible amount of time (5-7 minutes). The tablet computers used are Samsung series galaxy tab-S running Android OS. The teacher can also use a laptop running Windows. A laptop allows you to use previously purchased equipment and software which is available in the school laboratory.

The pre-installed software allows the teacher to fully control the students' tablets, up to blocking their work. The ability to recognize handwritten text allows you to write the resulting answers instead of using the obsolete method of choosing the correct answer from the proposed list.

To ensure maximum comfort and manageability when using, tablet computers in the workplace of students must meet the following requirements:
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- a continuous battery life of at least 6 hours;
- a screen resolution of at least 2560x1600 pixels;
- a screen diagonal of at least 10”;
- the support of an electronic pen to enable handwriting;
- hardware and software support for remote control to enable the teacher to control the device of a student;
- confirmed compatibility with the requirements of cryptographic protection against unauthorized copying of electronic content.

III. RESULTS AND DISCUSSION

In the process of the formation of electronic content for the system of basic and secondary general education, it was taken into account that the unique operational mission, which penetrates almost all scientific spheres, is performed by mathematical science in the synergy of scientific knowledge. In this regard, the content presented mathematical knowledge in a form that allows connecting its origin with practical application in natural and technical sciences and built logical and meaningful connections between mathematical, natural science and other cycles of academic disciplines [3].

Virtual reality is created as a three-dimensional environment which the user can interact with, immersing fully into it. Many researchers believe that virtual reality makes it possible to find and function in environments that are not reachable to people for reasons of distances [6, 7].

The emergence of VR-technology opens up new approaches for the practical study of foreign languages and bringing knowledge to a fundamentally new level for a large number of students who will receive the opportunity to plunge into VR for learning. For example, one of these approaches is the active involvement of students in the process of motivated speech activity. It is also possible to increase the progress in learning a foreign language by motivating to learn through VR-simulation, being “far away” from teachers and classmates and having speech practice in private.

For the process of learning foreign languages the project provides for the use of a GEAR VR helmet with a Samsung Galaxy S7 and higher smartphone running the Android OS.

The pre-installed educational content is game simulations tied to the topic being studied. Scenarios of simulations involve the implementation of simple tasks with the possibility of verbal interaction. The time of one scenario meets the Sanitary and Epidemiological requirements for the conditions and organization of learning process in educational institutions (SanPiN “SanPiN” in Russian) 2.4.2.2821-10. These requirements determine that continuous work with the images on a personal computer monitor and keyboard should not exceed for the 1-4 classes - 15 minutes, 5-7 classes - 20 minutes, 8-11 classes - 25 minutes. Approximately the same restrictions are set on viewing static and dynamic images on smart boards and reflected light screens. At the same time there is no difference between the chalkboard and the interactive board.

Visualization refers to the ability of the brain to see objects in images. Practical application of visualization techniques in the modern world were conducted by Doctors Stephanie and Carl Simonton, who in the 1970s developed a method in which special attention was paid to visualization techniques, overcoming fear and setting goals. Today this basic visualization technique in the meditative state has a wide variety of individual variations and a wide range of applications, one of which is the study of foreign languages [23].

A.A. Verbitsky considers the use of various visualization techniques in teaching and learning process ensures its intensification, activation of educational and cognitive activity, formation and development of critical and visual thinking, visual perception, visual representation of knowledge and educational actions, transmission of knowledge and image recognition, enhancement of visual literacy and visual culture. The use of visualization techniques involves the entry of a student to a higher level of cognitive activity and stimulating of students’ creativity [12, 25].

According to the requirements of the Common European Framework of Reference (CEFR), students’ foreign language skills are divided into 3 broad divisions (level groups): level group A - basic user, level group B - independent user, level group C - proficient user; each of which in turn is divided into 2 groups (levels). Each level describes what a learner is supposed to be able to do in reading, listening, speaking and writing. To practice speaking skills at levels A2, B1, B2 and higher creative techniques and approaches are required. The immersion into a language environment using Virtual Reality Technologies (VR technologies) can become the optimal environment for successful learning of a foreign language. In this environment, it is possible to simulate verbal interaction in the atmosphere of foreign language speaking society.

The work of T.A. Syrina gives an overview analysis of the visualization method in language learning process from the point of view of cognitive visualization [24]. A.V. Mishina considered two theoretical ways of the use of visualization technologies in the process of learning of a foreign language [13]. The first is the augmented reality technology, which allows to supplement the image of real objects with different models of computer graphics, combine images from different sources, and also supplement reality with the introduction of synthesized objects into natural video scenes. The second is the technology of virtual reality, which involves a completely artificial synthesized world (video sequence). Interactive visualization methods involve interaction with the learner.

IV. CONCLUSION

Currently, there are many opportunities to create the effect of language immersion: text, audio and video (presentations, films) information resources, games, training and monitoring programs, online education with the ability to download and install on any media, as well as chat rooms, Skype, E-mail, distance learning, including webinars, video conferences, etc. [8]. Moreover, trying to recreate a kind of “foreign” atmosphere for students, foreign language classrooms are
designed in the style of the country of the language that is being studied in this classroom.

To ensure the possibility of verbal interaction, artificial intelligence (AI) technologies are used, in particular, speech recognition and synthesis. The project uses the Pocket Sphinx software solution and a specially developed service for streaming data from a microphone through a web browser API, via the Websocket library.

For visualization in classrooms, the working project provides for the use of a touch panel with a diagonal of 75" and direct LED backlight technology. This will allow conducting classes without additional dimming of the classroom and meet the requirements of SanPiN. Special software is designed to create a universal solution and allows you to use information materials created for any platforms (for example, iOS, Android, Windows, etc.).

Let us note a few points to which particular attention was paid when designing a virtual reality:
- VR technology brings positive results when used in short sessions, or in the form of simulations;
- it is not advisable to use VR technology for lectures and seminars;
- developing software solutions, we focused on the latest models of VR equipment, the most environmentally friendly and ergonomic for users.

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