USING EXTENDED REALITY TECHNOLOGY IN EDUCATION

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Abstract. *The article presents the results of a study on using extended reality technology in education. Education, as one of most important field, willing to use modern technology to make educational process more efficient and effective for different students. Extended reality (XR) allow people to study from any place of the World with the internet connection, differently from just video communications technologies, XR allow to fill that user is in the classroom surrounded by other users. This point provide socialization which is important for school age students, especially in war, pandemic, or other unpleasant circumstances, while currently used video communications technologies cannot provide same experience and working only as a "data flow" which lead to degradation in communicational and social skills. In this paper mix of qualitative (observations) and quantitative (databases) methods were used in order to observe current stage of XR technology, its development and implementation, determine current challenges of XR in education. Furthermore, patent analysis was conducted for better understanding of XR development direction and biggest influencers among countries. It had been discovered that implementation of XR in education is only at the beginning stage, there are no training centers for teachers, no state policy that regulate using XR and technology is still relatively expensive so majority of educational institutions and states cannot afford it. In addition, the active development phase started in 2015, with China in a top according to amount of patented technologies. Despite the lack of researches about XR in education, some educational organizations already use it and create their own software to support XR. Positive dynamic and unarguably benefits that provide XR technology, provide enough evidence to claim that in the future this technology would be a standard of education.*

Keywords: *extended reality, augmented reality, virtual reality, education, patent analysis, technology innovation.*

JEL Classification: A22, A23, M53

Formulas: 0; fig.: 5; tabl.: 1; bibl.: 14

Introduction. The use of mobile Internet devices expands the boundaries of the traditional information and educational environment of the university to an extended realty (XR) technology-oriented - open multidimensional pedagogical system that includes psychological and pedagogical conditions, mobile information and communication technologies and teaching aids, research and education management, and provides interaction, cooperation development of the personality of teachers and students in the process of solving educational and scientific problems at any time and in any place. One of the ways to increase the efficiency of technology-oriented learning environment is the use of augmented reality technology, which provides an opportunity to combine real and virtual learning tools using Internet devices.

Research in the field of extended reality was conducted by Chisinau, Codell, Maisel, Milgram, Sutherland and other scientists. Their works addressed the problems of classification, development and use of extended reality in the educational process and in professional activities. In particular, the works of Guayel, Martin-Gutierrez, Karabin, Restivo, Rizova, Siotata, Hugh confirmed the positive effect of the use of this technology in education and provided an opportunity to identify the use of augmented reality (AR)and virtual reality (VR) technology as one of the most promising areas for

improving the efficiency of the learning process in education system.

The concept of virtual and augmented reality has been evolving since the 1960s and is considered a very promising, powerful and useful tool, especially in education. Augmented reality is defined as the combination of physical and digital spaces in semantically related contexts for which the objects of associations are located in the real world. Unlike virtual reality, the augmented reality does not create a completely virtual environment, but combines virtual elements with the real world: virtual objects are added to the real environment of the user, which changes as a result of his actions (Cieutat, 2012).

Literature review. Sutherland the "father" of modern user interfaces, in 1968 points out that this requires the creation of virtual tools or user-managed components for performing certain experiments. The virtual and augmented reality helmet he developed is named "Sword of Damocles" - due to its large weight and size, the mechanism was permanently mounted above the user (Sutherland, 1968).

Thus, the lack of mobility of extended reality technology has become a major obstacle to its spread - more than 30 years of research in this area has not gone beyond individual laboratories. The theoretical result of this stage was the work of Milgram: the authors describe the space between the real and virtual world (calling it a combined reality), in which extended reality is closer to the real (not modeled) world, and extended virtuality - to the virtual (fully modeled) world (Milgram, 1994).

With the advent of mobile devices in the 1990s that the technological preconditions get up for the use of extended reality technology outside of specialized laboratories - in the mobile space of the Internet user. On the basis of XR technology, mobile software tools have been created to study various disciplines (socio-humanitarian, fundamental and professional). These tools provide information about educational facilities and their characteristics. In a number of projects in North America and Europe, mobile devices have been used to visualize augmented reality virtual objects. Thus, with the help of software for mobile devices, future engineers could see where the bridge supports are located during their visual inspection at different angles (Martin-Gutierrez, 2014).

Restivo, considered the possibility of applying AR and VR technology in teaching physics. Researcher point out that, despite the widespread research approach in teaching, students are not always able to perform an experiment in a classroom due to lack of time or materials. Performing experimental work in extracurricular time carries additional risks, especially when working with dangerous materials. The use of modern technology provides a safe way to perform experiments both under the guidance of a teacher and independently. Augmented reality experiments and sensory devices visualize real research for users and are aimed at giving students the opportunity to observe and describe the work of real systems when changing their parameters and partial replacement of material resources and experimental installations by objects of augmented reality (Restivo, 2016).

Rizov, considering the use of extended reality in the teaching of engineering graphics, introduce the concept of "prepared" and "unprepared" scene (virtual modeling space). If XR software is planned to be used in an "unprepared" scene

(usually outside the audience), then to determine and track its status requires additional hardware - gyroscopes, GPS-navigators, compasses and more. For classroom use, it is advisable to "prepare" the scene - in this case, the position and tracking is carried out using appropriate reliable black-and-white markers of characteristic shape (square or circle), specified by the software architecture for their detection and tracking (Rizov, 2017).

Karabin notes, that augmented reality can be used for students to work together. This is especially important in the process of laboratory work with potentially dangerous equipment that requires constant monitoring of student activities. Real laboratory work is preceded by AR work by placing markers on laboratory installations. Using markers, students will be able to use a mobile device to visualize the instructions or learning materials needed to properly use and configure the equipment. (Karabin, 2019).

To sum up, the use of extended reality technology in a technology-oriented learning environment:

1) expands the capabilities of laboratory facilities used to prepare students to work with real systems;
2) makes available systems of high complexity and cost, which have traditionally been available only to specialists;
3) provides laboratory simulators with augmented reality interfaces, which helps to improve training;
4) motivates students to experimental and research work.

Aims. The purpose of the article is to observe current stage of development and XR technology in educational sphere, examine challenges that slowing down implementation of XR.

Methods. The main research methods that were used in the article are general scientific methods of analysis and synthesis, as well as comparative analysis, which became the basis for obtaining research results.

Results. Despite fact that nowadays XR technology consistently get improved and implemented in different educational institutions, there are lack of “groundwork” for technology to have mass character.

Usability of virtual and augmented reality technologies in educational institutions: challenges and risks. There are also a number of problems that prevent the introduction of extended reality technologies in educational institutions. In particular, despite the fact that Google Play and the App Store, Steam offer a wide range of mobile applications with AR and VR, the key obstacle still remains limited resources in educational institutions and the lack of non-English language content. It is also necessary to update teaching methods and improve the skills of older teachers, as the number of young professionals familiar with XR in schools is insufficient. (World Bank, 2020).

On the solutions of AR related issues working corporations such as Apple, Facebook, Vuzix, Microsoft, Google and many others. According to consulting firm ABI Researh, AR solutions are key factors setting new standards in learning, human resources and collaboration. The introduction of digital tools, including augmented

reality, in HR departments (HR) can accelerate the process of digital transformation of HR and increase the value of existing HR activities, especially after COVID-19. ABI team believe, that by 2025, there will be about 60 million active AR users who will use these technologies to gain experience and training in various fields, including healthcare, logistics, architecture, engineering, construction, etc. (ABI Research, 2021).

Thus, because of new challenges and technologies of extended reality, the educational industry is on the beginning of a new stage of its development - technological, efficient and interesting for students. We can be sure that new programs will appear in the future, and bot augmented and virtual reality technology will be improved and implemented in even more processes in education. But AR/VR is still not widespread in education in any country. At present, XR technologies are not widely used in education, and there are a number of reasons for this.

Firstly, educational system is not prepared for restructuring and rethinking. XR today can be considered only as a supplement to the educational process, but not as an alternative. The transition should be smooth, appropriate research should be performed, focus group success should be studied, and appropriate conclusions should be made. It is possible that excessive enthusiasm for this form of education may lead to an improvement in the educational process in one area, but deterioration in another. In any case, it should be taking into account that modern students are so accustomed to gadgets that it is better to receive all information through a cell phone, computer or tablet, and this requires the use of new technologies in the educational process, diversification of teaching methods, etc.

Secondly, it is necessary to completely rethink and change the program of education. Working with such technologies has many factors that need to be considered when designing a program of study. It is required to clearly agree on all points of the program so that they do not interfere with each other.

Thirdly, it is still the high cost of equipment for mass use of XR in education. Moreover, there is a lack and variety of training programs to use as an alternative to classical teaching methods and tools. In addition, a small number of trained professionals, as the use of XR technology in education requires the training of teachers who will work with children, adolescents and students, and this requires time and appropriate training courses to be implemented at the state level.

Despite the benefits of extended reality technology, humanity will soon face three paradoxes: mobility, isolation and social integration. The paradox of mobility is that XR allows you to get anywhere, but with it a person does not go anywhere. The paradox of isolation - XR allows you to communicate with people from any country, but at the same time isolates from physical communication. The paradox of social integration is that people who find it difficult to socialize prefer virtual communication (Nekrasov, 2020)

Analysis of XR technology in Medicine as example of innovation. One of the first areas of application of technology is surgery and the consequences of its manipulation. A large number of patients suffer from phantom pain that occurs during amputation of one part of the body. This phenomenon is one of the most serious neurological

problems. It happens that the pain experienced by the patient becomes unbearable, and the only solution to this problem is to take painkillers. However, with the help of augmented reality technologies, a program was created that allowed patients with amputated arms to watch a picture online in which they had both hands. When using augmented reality technology, patients were asked to tense their muscles on a virtually created missing arm. By artificially creating an amputated arm in augmented reality, we "cheat" brain activity by seeing that the arm is not amputated, the human brain is gradually adjusting to this thought, which is why the intensity of phantom pain in the study described above is so significantly reduced (Khor, 2016).

Post-traumatic stress disorder (PTSD) has become a more common psychological disease. PTSD is a chronic mental disorder that can develop due to a traumatic event in a person's life. This pathology is reflected not only in the psycho-emotional state of the patient, but often has characteristic clinical manifestations. With the help of AR and VR technologies, patients are immersed in the circumstances in which they received psychological trauma. This method helps the patient to analyze the situation that happened to him and reduce their fears, so it is one of the fundamental in psychiatric practice. (Fiani, 2020).

Alzheimer's syndrome is a chronic disease that causes slow damage to neurons and death of brain tissue. During the course of the disease, memory, mental abilities, and the ability to cope with everyday affairs gradually deteriorate. In order to simplify people's life, a technology combining AR and VR technologies was proposed. In this way, short films are created in virtual reality mode, which will remind people of things related to his life. Augmented reality technologies are used to overlay images with instructions for the operation of an object, in order to adapt a person to the situation.

Parkinson's syndrome, is a very serious chronic disease with hard diagnostic, which means that it is almost impossible to prevent the development of the disease. However, with the help of AR and VR technologies the patient is immersed in a virtual environment in which his virtual position in space changes, while special sensors monitor changes in body position in the physical world, and the inner ear helps maintain proper balance. If a person is easily out of balance and unable to regain it, then there is a reason to consult a specialist. It follows that augmented reality technology is the basis for early diagnosis of Parkinson's syndrome. (Li, 2019)

Discussion. For better understanding of XR development direction and biggest influencers among countries patent analysis was conducted. The global patent annual trends is given in Figure 1. After searching in Web of Science: Extende* realit* AND education* OR XR AND education* OR augmente* realit* AND education* OR AR AND education* OR mixe* realit* AND education* OR MR AND education* OR virtua* realit* AND educatio* OR VR AND educatio* and filter by Derwent Innovations Index only we get 1557 results.

First patent was registered in 1990 however, until 2008 there was no more than 5 patents registered annually. So first step in developing extended reality in education were done from 2008 to 2015 with near 40 patents per year. But from 2015 amount of patent application increased significantly and reached its peak in 2020 with 297 registered patents. Now we see that graph is declining but 2020-2021 we get COVID

pandemic which may be partly responsible for declining pandemic influence all world.

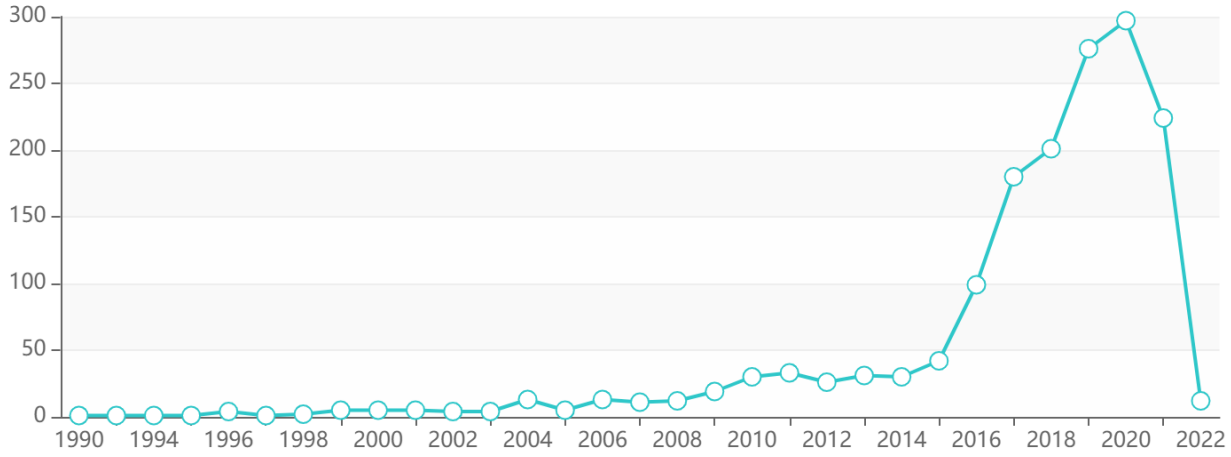

Figure 1. Global patent annual trends

Source: Created by the Author based on database from https://www.webofscience.com/wos/woscc/basic-search

In graph 2 clearly shown that China is registered 41,5 % of all patents related to XR in education. PRC followed by South Korea with almost 450 patents, United states of America with approximately 250 patents and World intellectual property organization with just above 100 patents. All other countries represented in the graph, have insignificant contribution. It is shown, that Asian region have higher interested in XR technologies than other continents.

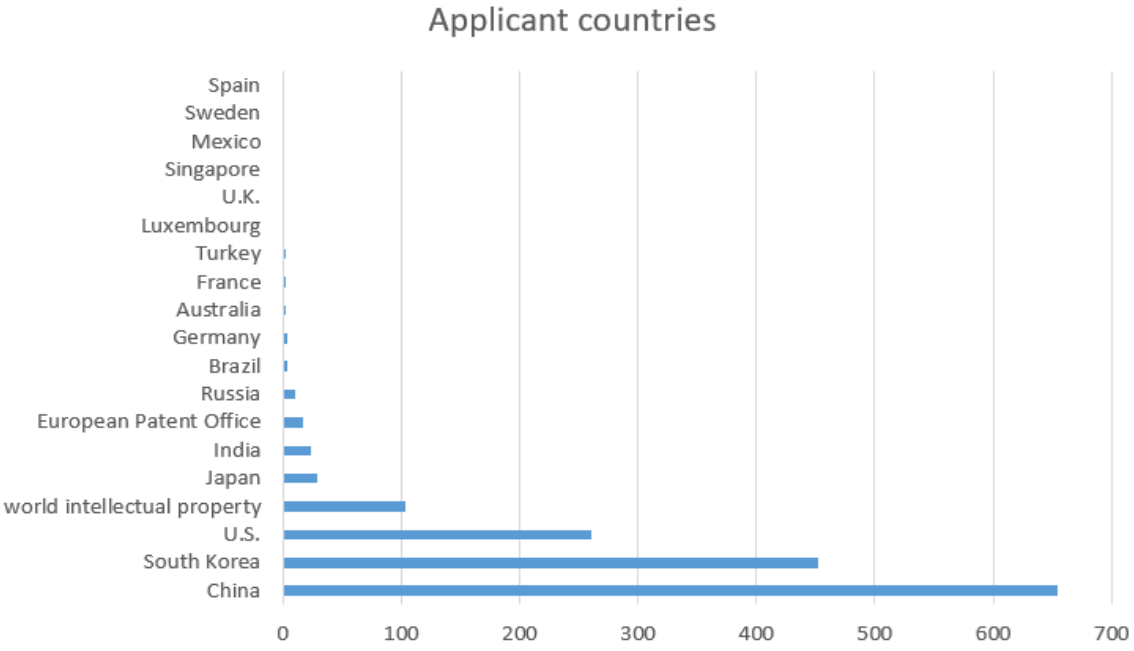

Figure 2. Analysis by countries of patent application

Source: Created by the Author based on database from https://www.webofscience.com/wos/woscc/basic-search

According to third graph, the first country which applied for XR technology in education patent was America, nowadays USA is in top 3 countries contributed to extended reality technologies. So it's obvious that America find this technology perspective.

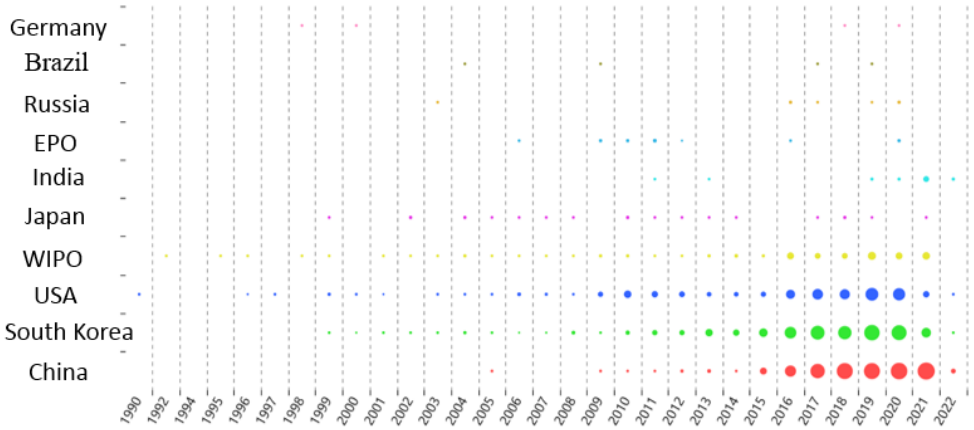

Figure 3. Application time-application country

Source: Created by the Author based on database from https://www.webofscience.com/wos/woscc/basic-search

Current leader – China make its first patent only in 2005, one of the last countries, but ten years later, science 2016 increased its participation significantly, outperformed its nearest concurrent South Korea.

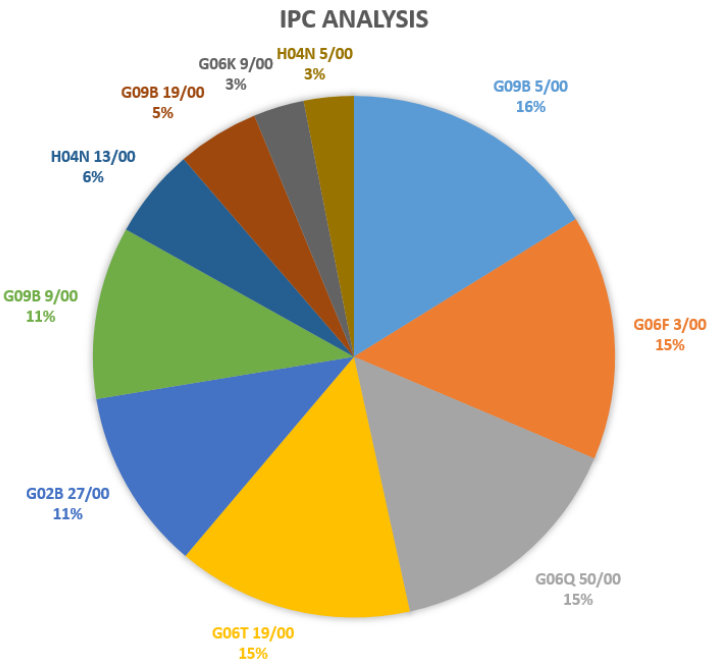

Figure 4. IPC Analysis

Source: Created by the Author based on database from https://www.webofscience.com/wos/woscc/basic-search

The diagram represents that different aspects of XR technologies in education developed relatively even. Biggest category G09B 5/00 (Electrically operated teaching aids, 16%) is followed by G06F 3/00 (input/output device to converting and transferring data, 15%). This demonstrate that software and hardware are developing evenly, however, there are not enough software to massively implement the technology in educational systems of countries.

Table 1. IPC Classification

IPC	Classification
G09B 5/00	Electrically operated teaching aids
G06F 3/00	An input device for converting data to be processed into a form that can be processed by a computer; an output device for transferring data from a processor to an output device, for example, an interface device
G06Q 50/00	A system or method specially adapted to a specific business sector, [Education, 2012.01]
G06T 19/00	Manipulation of three-dimensional models or images for computer graphics [2011.01]
G02B 27/00	Other optical systems; other optical instruments (devices for producing special optical effects in shop windows or display cases, for example, A47F 11/06; optical toys in A63H 33/22; designs or drawings featuring special optical effects in B44F 1/00
G09B 9/00	Simulators for teaching or training
H04N 13/00	Stereoscopic television systems; parts thereof
G09B 19/00	Teaching aids not included in the other large groups of this subclass (teaching or practical apparatus for aiming and shooting in F41G 3/26
G06K 9/00	Methods or apparatus for reading or recognizing printed or written characters or for recognizing figures, for example, fingerprints (methods or apparatus for reading diagrams or converting figures of mechanical parameters such as force or state into electrical signals) G06K 11 /00; speech recognition into G10L 15/00)
H04N 5/00	Parts of television systems (scanning parts or their combination with the supply voltage into H04N 3/00) [2011.01]

Source: Created by the Author based on database from https://www.wipo.int/classifications/ipc/en/

According to 15% of G06Q 50/00 (a system or method specially adapted to a specific business sector) some educational organization already creates the methods which will allow use of XR technology in the learning process. Smaller parts include, simulators of teaching training, 3d modeling, optical, television and stereoscopic system. So the XR technology used in education can have different forms and use diverse range of sensors engaged, but, they all have one mission – to make teaching process available, in different situations like war or pandemic, interactive and interesting for kids.

The world cloud analysis includes 50 words that often appear in scientific papers. The most repeatedly used words where ‘learning’, ‘augmented reality’, ‘students’, ‘education’, and ‘technology’. It is remarkable, that “extended reality” did not appear in the cloud world but all, “mixed”, “virtual” and “augmented” reality did it. Also, mobile device and learning presented in the world cloud, almost as much as terms related to medicine. Notable, word “autism” also presented which mean that using of XR technologies was considered as a method of teaching for the students with special needs. In this cloud, darker colors represent relevant topics of the past years while brighter – modern.

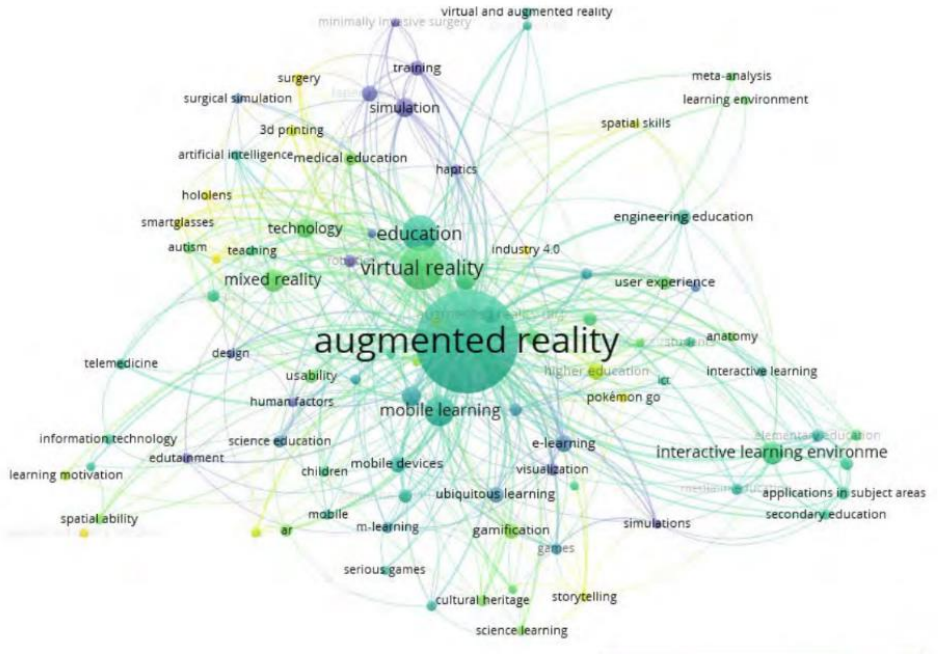

Figure 5. World Cloud

Source: Cecilia, A. G. (2021). Augmented Reality in Education: An Overview of Twenty-Five Years of Research. *Cont Ed Technology*, vol. 13. P. 13. *Retrieved from*: https://doi.org/10.30935/cedtech/10865

Despite the significant advantages of integration into the educational process of the outlined tools, there are a number of organizational problems, namely: it is necessary to train teachers and research and teaching staff, especially in the use of AR and VR in teaching disciplines, as well as in the development and implementation means of this type in the educational process.

Conclusion. To sum up, since extended reality is already being actively implemented in many areas of human activity, its development with the help of available content and relevant courses is an essential prerequisite for the development and gradual introduction into the education system. Technologies that help create interactive lessons in virtual reality, using photos360, video360, 3D models and other media, will soon reach a mass character, especially since the use of virtual reality in education is possible at any age: and younger students, and people of different ages who have decided to learn a new profession or improve their skills. At the same time, it is important to remember that the virtual education system cannot be considered complete, at least today, and should therefore be seen only as a supplement to the learning process - as an effective tool in the learning process. And might be consider as full replacement of traditional education only in lack of other options (if its war, pandemic or student have special needs).

Summarizing, it should be emphasized that AR and VR are quite powerful technologies for improving the educational process, but research into their effective use is at an early stage.

Future scientific research in the direction of didactic principles of using AR and VR at different stages of the educational process, as well as to develop them for specific fields of knowledge and disciplines have be done before implementing the technology massively.

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