USE OF AUGMENTED REALITY TECHNOLOGIES IN THE EDUCATIONAL PROCESS TO VISUALIZE EDUCATIONAL MATERIAL

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Abstract

The article discusses augmented reality technology, provides a brief overview of existing solutions and methods of using augmented reality, and highlights its relevance in the field of education in the context of rapid development of science, technology and engineering. The application of augmented reality to education is described in detail.

The authors also proposes a classification of augmented reality technologies for education and provides examples of educational materials that use this technology.

Conclusions are drawn regarding the use of augmented reality technologies in education, which will increase motivation to learn, promote better assimilation of information due to the diversity and interactivity of its visual representation, allow transferring part of the students' research work to the field of distance learning, improve learning conditions, promote the development of research skills, memory, imagination, thinking, emotional intelligence.

Keywords: Augmented Reality, AR-Technology, Interactive Learning in Education.

INTRODUCTION

Modern society is undergoing a series of transformations that undoubtedly impact the field of education. Pandemics, natural disasters, conflicts, and rapid digital revolution present new challenges for the education sector. One of the most pressing issues is ensuring the sustainability and accessibility of education in a changing world. In this context, the use of augmented reality (AR) technology becomes particularly relevant as it can serve as a valuable tool to address challenges associated with crises and the digital transformation of education.

For example, the COVID-19 pandemic led to the temporary suspension of in-person learning in many countries and highlighted the need for new approaches to ensure learning in times of quarantine restrictions. Simultaneously, digital transformation has shifted education to the online environment, necessitating adaptation by both teachers and students to new technological realities [1].

Several key factors, such as quarantine restrictions, warfare, remote learning, and the overall transformation into digital education, require the integration of innovative technologies into the educational process.

Let's break down the main issues into understandable components that have led to the development of innovative approaches and describe them.

1. Quarantine restrictions have forced the education process into the online realm, demanding the use of modern technical devices and educational tools. Contemporary technology and software are actively incorporated into the learning process.

2. Remote learning: the development of technology and changes in lifestyle call

for new forms and methods of education. Remote learning is becoming increasingly popular, but questions arise regarding its effectiveness and accessibility for all learners.

3. Digitalization of education: the shift to remote learning and the transition to digital education require the development, content creation, and effective implementation of online courses. The incorporation of digital educational resources into remote learning offers significant opportunities but also demands considerable efforts in technology adoption and enhancing the digital competence of both educators and learners [2].

Therefore, the challenge lies in ensuring the continuity of education and enhancing its quality in the face of new challenges. One solution is the utilization of augmented reality technology to enhance the visual aspects of the educational process. When practical sessions in laboratories or hands-on experiences are not possible, augmented reality technologies can immerse learners in what appears to be a real environment where they can interact with virtual objects and surroundings [3]. Additionally, for explaining theoretical material that requires advanced spatial imagination and might be difficult to comprehend, augmented reality effects can be used to illustrate concepts. The use of augmented reality technologies in education is one of the most promising innovations in contemporary pedagogy.

In the modern world, augmented reality is becoming an increasingly important part of our everyday lives and finds broad application in various fields, including education, medicine, business, marketing, entertainment, and more.

Augmented reality technology allows us not only to observe the real world but also to expand it, adding virtual objects, information, and interactivity. It establishes a connection between the physical and digital environments, enabling new ways of perceiving and interacting with information.

EXPOSITION

In this article, the authors propose to explore the application of augmented reality (AR) in the educational process and its role in teaching and learning.

The relevance of augmented reality in the modern world is hard to overestimate, as this technology has become a key tool in various spheres of life. It provides the opportunity for virtual interaction with educational materials, enhances productivity in manufacturing, expands advertising and marketing possibilities, creates immersive gaming experiences, and enables the visualization of concepts in design. Augmented reality also finds applications in medicine for improved diagnosis and treatment and in the military field for training and combat simulations. All of these aspects make augmented reality an important innovative tool with the potential to transform various areas of life and pave the way for a more interactive and engaging future.

The goal of justifying the use of augmented reality in the educational process lies in uncovering the potential of this technology to enhance education. Augmented reality can create interactive and immersive learning experiences, individualize learning, engage students actively, develop technical skills, and prepare them for future challenges. This technology opens up new possibilities for creating accessible and high-quality education that adapts to modern requirements and promotes the development of competencies needed in the contemporary world. This is why it was decided to apply augmented reality technologies in the study of natural science subjects for 8th-grade students.

Here are several key positions where this can be beneficial:

1. Enhancing material comprehension: visualizing educational material, making it more accessible and understandable for students. Interactive virtual models and

simulations can visualize abstract concepts, helping students better understand them [4].

2. Engaging students in learning: an engaging tool that motivates students to actively participate in lessons. Game elements and virtual challenges can make learning interesting and exciting [5].

3. Individualized learning: creating individual learning paths for students. Teachers can adapt the material to the needs and level of preparation of each student, allowing them to learn at their own pace.

4. Visualizing complex processes: visualizing complex algorithms, programming processes, and data structures. Teachers can create virtual simulations that demonstrate how computer programs work in real time.

5. Preparing for the digital world: developing skills and competencies that are important in the digital world. Students learn to interact with modern technologies and understand how they function.

6. Strengthening collaboration and communication: promoting teamwork among students and developing communication skills in the electronic environment. They can interact in virtual projects and tasks, learning to collaborate and exchange ideas [6].

Augmented Reality (AR) is a technology that allows for the real-time combination of virtual objects or information with real-world objects in the surrounding environment. The main idea of AR is to augment or enhance the real world with information that can be educational, informative, entertaining, or functional. For example, AR can overlay virtual animations on a book's image, display information about places around you during travel, use AR apps for learning, create gaming applications, and more [7].

AR offers several benefits and applications in education:

✓ Enhanced Understanding of Abstract Concepts: AR enables the creation of interactive educational resources that help students better understand abstract concepts. For example, in chemistry, students can explore the 3D molecular structure of substances, facilitating the comprehension of complex chemical processes.

✓ Interactive Simulations: AR can be used to create interactive simulations. For instance, when teaching medical skills, students can use AR for virtual surgeries or disease diagnostics, allowing them to practice skills without the risks associated with real patients.

✓ Engagement with 3D Objects and Virtual Tours: students can interact with educational content in the form of 3D objects, virtual tours, animations, and more. This immersive experience makes learning more engaging and allows students to dive deeper into the subject.

✓ Gamification of Learning: AR simplifies gamification in education. By introducing gaming elements and tasks through AR platforms, educational institutions can stimulate competition and collaboration among students, enhancing motivation for learning.

✓ Simplified Teaching and Assessment: AR makes it easier for teachers to explain complex concepts and track students' progress.

✓ Showcasing Innovation and Attractiveness: schools, universities, and training centers actively incorporating AR can enhance their competitiveness by showcasing their innovative approaches to education.

This study involved a pedagogical experiment to implement AR technology during lessons in the natural sciences: informatics, mathematics, physics, and chemistry in two classes (8-B and 8-C). The research aimed to compare the learning outcomes of students in these classes where different digital technologies were employed in teaching. In the 8-C class, AR technologies were used, while traditional teaching methods were used in the 8-B class.

Pedagogical Experiment Stages:

1. Development of Teaching Methods Utilizing AR:

✓ Augment, an AR app, was used to teach digital devices during informatics lessons.

✓ CleverBooks Geometry, an AR app, was employed for geometry lessons to study flat and three-dimensional shapes.

✓ LiCo.Organic, an AR app, was used for chemistry lessons to study organic compounds.

✓ Da Vinci Machines, an AR app, facilitated physics lessons to learn about kinetic and potential energy, frictional force, elastic force, and the law of conservation of momentum.

2. The application of AR technology in these lessons aimed to assess its impact on students' engagement, comprehension, and overall learning outcomes compared to traditional teaching methods.

✓ Comparison of Basic Academic Achievements in Natural Sciences.

✓ Control tests were conducted in all the mentioned subjects, with maximum scores, minimum scores, and average scores determined for students in both classes for each subject and overall for the natural sciences disciplines.

A comparison was made between the control and experimental groups using the Wilcoxon-Mann-Whitney test, assessing the homogeneity of the groups and the correctness of conducting the experiment [8]. In the concluding stage of the experiment, 28 students from class 8-B participated, while in the formative stage, 26 students from class 8-C were involved. Since the concluding and formative stages of the experiment were conducted with different groups, these samples are considered independent. By calculating the observed statistic value and comparing it with the critical value of the statistic and the two-tailed Wilcoxon-Mann-Whitney test, the null hypothesis is accepted, indicating that "the initial knowledge and skills of students in both classes do not have significant differences." In other words, the groups are considered suitable for the experiment.

3. Conducting Lessons Using AR Technology.

✓ In the informatics lesson on the topic of "Digital Devices," models of various devices were studied. The Augment app allows the integration of pre-created 3D models into the real space in real-time through the camera. It is primarily focused on tasks such as demonstrating ready-made models. Since it is not possible to see all types of modern computers in person, this can be done through the AR app (Figure 1).

✓ In the geometry lesson on the topic of "3D Shapes," the CleverBooks Geometry program presents 3D models with augmented reality for basic geometric shapes. Students can interact directly with these shapes, aimed at improving their spatial thinking. Figure 2 illustrates visual materials in both traditional and AR-enhanced formats.

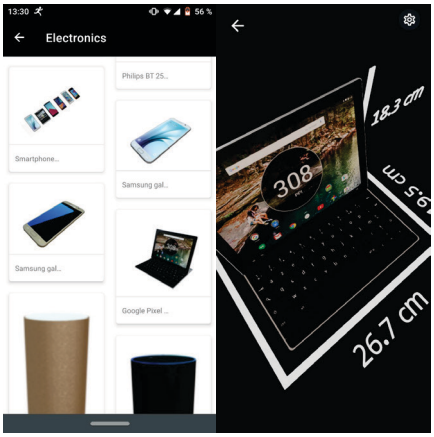


Figure 1. *Demonstration of Device Models through the Augment App*

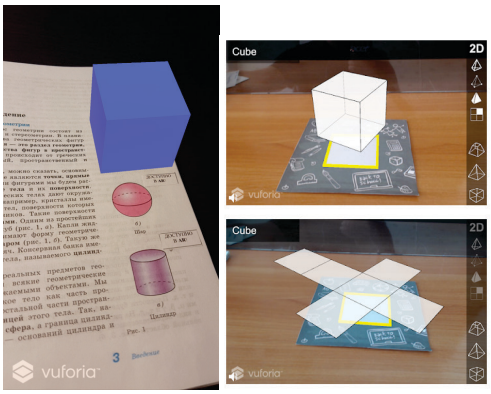


Figure 2. *3D Models with Augmented Reality for Basic Geometric Shapes*

✓ During the chemistry lesson, organic compounds were studied. Using the LiCo.Organic program, it's possible to scan images of organic compounds provided in the book and reproduce their three-dimensional representation in augmented reality mode. Figure 3 demonstrates the AR application in action.

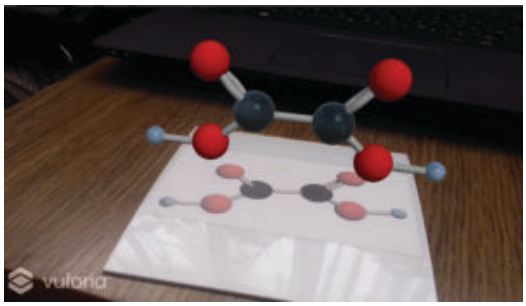
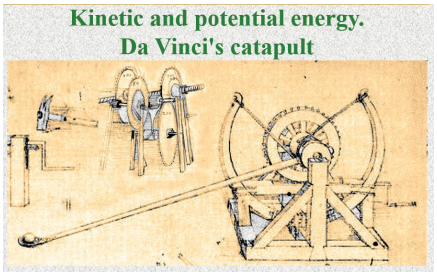


Figure 3. *Three-Dimensional Representation of Organic Compounds*

✓ During the physics lesson, the topic "Kinetic and Potential Energy" was studied using the example of the Da Vinci catapult. The topic "Law of Conservation of Momentum" was explored through the example of the Da Vinci tank, and the topic "Elastic Force and Frictional Force" was demonstrated using a self-supporting bridge. Figure 4 illustrates the instructional material in both traditional and augmented reality formats.



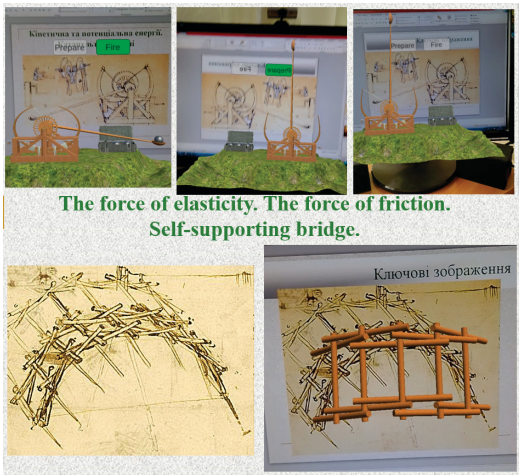


Figure 4. *Traditional and Innovative Teaching Tools*

4. Conducting a control measure to ascertain and evaluate the acquired knowledge in students from both classes. This involved administering control tests, assessments, and individual assignments.

5. Comparing the students' achieved academic results in both classes for subjects within the natural sciences curriculum (with a maximum score of 12).

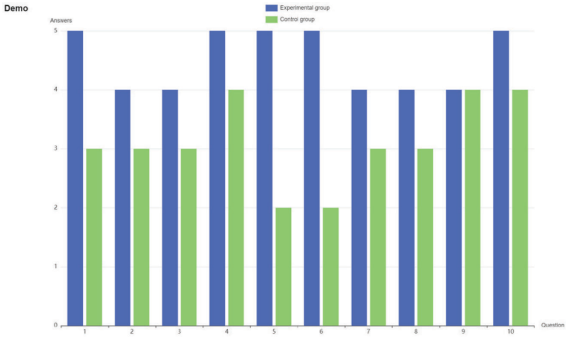
Following the administration of control tests in subjects that served as the content environment for the natural sciences disciplines in the experiment, the following results were obtained (Table 1).

When comparing the obtained results, it is evident that students in the experimental group have significant advantages over students in the control group. The academic performance of students in all subjects has significantly improved.

Table 1
Results of the Pedagogical Experiment

Subjects	Informatics			Geometry			Physics			Chemistry			Natural Sciences disciplines		
Indicators for comparison	Max score	Min score	Average score	Max score	Min score	Average score	Max score	Min score	Average score	Max score	Min score	Average score	Max score	Min score	Average score
Control group	9,3	6,5	7,9	9,1	6,3	7,7	8,1	6,3	7,2	8,1	6,2	7,15	8,65	6,33	7,5
Experi-mental group	10,4	7,2	8,8	9,8	7,1	8,45	8,9	7,1	8,0	9,1	7,0	8,05	9,55	7,1	8,33

6. Conducting surveys to assess students' interest in the learning process, their perception of educational materials, willingness to actively participate in class, and readiness to complete homework assignments. The survey results also indicated that students in the experimental group are more lively, active, and enthusiastically engage in the learning process compared to students in the control group. They are more actively and effectively completing tasks for independent work, have higher motivation for learning, and as a result, achieve higher academic performance (Figure 5). When surveyed, students in the experimental group unequivocally expressed support for the use of augmented reality technology in the learning process.



#	Question	Experimental group	Control group
1	Do you use the internet for additional learning or self-education?	5	3
2	How do you assess your computer literacy?	4	3
3	Do you use augmented reality (AR) in your education?	4	3
4	Do you know any applications for using AR in education?	5	4
5	How do you evaluate the benefits of using AR in education?	5	2
6	Do you believe that using AR improves the quality of education?	5	2
7	On a scale of positive outcomes, how much do you consider the use of technology in education?	4	3
8	On a scale of negative outcomes, how much do you consider the use of technology in education?	4	3
9	Are teachers involved in the use of AR in the teaching process?	4	4
10	Is it possible to ensure more equality in access to educational technology among students?	5	4

Figure 5. *Survey of students from two groups*

7. Formulating conclusions regarding the effectiveness of using AR technologies in the educational process.

Based on the analyzed experimental data, the authors have reached the following conclusions: students in the control and experimental groups have different attitudes towards the learning process, varying levels of comprehension of educational material, and different levels of knowledge and skills. They also exhibit different levels of motivation and interest in learning.

Regarding the use of AR technologies by teachers, the opinion has formed that the integration of AR technologies into educational programs can be an effective tool in the hands of modern educators. The application of AR does not require significant expenditures on technical retooling and regular modernization, as the primary component is educational content that can be updated and added to by the educational community. The development of high-quality educational AR materials is a task that will remain relevant in the near future.

Overall, the research provides compelling evidence in favor of using augmented reality in the educational process and its positive impact on students' learning outcomes and comprehension of material.

CONCLUSION

The research has shown that the application of augmented reality technology contributes to improving students' academic achievements, enhances their comprehension of educational material, and stimulates motivation for learning. It serves as a powerful tool for pedagogical support for teachers.

The use of augmented reality in the educational process is not just about applying advanced technology to learning; it is a powerful tool that can transform the way knowledge is acquired and skills are developed. AR technology opens up new possibilities for visualizing information, creating interactive educational games, personalizing learning, and actively engaging students in the learning process.

However, it is essential to remember that AR is a tool and should be used wisely, considering pedagogical objectives. Effective integration of AR into the

educational process requires significant efforts from teachers and educational institutions in creating quality content and educational programs, as well as ensuring technology accessibility for all students.

In the future, it is crucial to consider various aspects of using augmented reality in educational programs, including different subjects and age groups. It is advisable to determine the suitability of this technology for specific educational tasks. Researchers should investigate which aspects of augmented reality have the most significant impact on material comprehension and student motivation, identifying the most effective visual, audio, and interactive elements for application and further improvement of pedagogical practices. It is vital to study potential limitations and challenges associated with the use of augmented reality in education, such as technology accessibility and its impact on students' social adaptation. This will help develop strategies for overcoming possible obstacles.

Overall, the research confirms that augmented reality has significant potential for improving the quality of education and preparing the new generation for the modern world, making learning more engaging, understandable, and aligned with contemporary requirements. The authors have plans for implementing augmented reality technology in the teaching of humanities subjects and developing a methodological seminar for teachers to build and enhance their digital competencies, specifically in using augmented reality technologies for teaching educational material.

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