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Integration Of Ar-Technologies In Teaching Robotics And Microcontroller Programming

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Abstract: *This study examines the utilization of innovative approaches in teaching robotics and microcontroller programming with augmented reality (AR). It explores how AR technologies not only enhance the educational process but also help overcome traditional barriers encountered by students when learning complex technical skills. The research underscores the importance of integrating AR technologies to create interactive and personalized educational environments where learners can visualize and interact with virtual models of robots and microcontrollers, thereby deepening their understanding of technical concepts. Special attention is given to the impact of AR technologies on stimulating students' interest in science and technology, as well as reducing obstacles in learning robotics. The study presents the results of using AR technologies in education and argues that incorporating these technologies into educational programs can significantly transform the teaching of robotics and microcontroller programming, preparing students for the challenges of the modern world.*

Keywords — AR technologies, education, robotics, learning, innovation, augmented reality, microcontrollers, programming.

Introduction:

The growing digitalization of society cannot be ignored in the field of education. Thus, the study of the possibilities and perspectives of the use of digital technologies in higher and secondary education is being updated. The didactic possibility of modern digital technologies and their application in education is one of the current directions of scientific research. The application of Augmented Reality (AR) technologies in educational practice shows promising potential.

Virtual (VR) and AR technologies occupy an important place in the new stage of innovative development of society, known as Industry 4.0. These technologies have both common and distinctive features, which are reflected in the specifics of their application by companies in the process of creating relevant products. VR and AR technologies involve the creation of thematic visual content that can be used by the target audience to meet specific needs with the use of modern electronic devices.

When exploring the impact of AR technologies on robotics education, it is necessary to focus on the methodology and benefits of incorporating these technologies into the classroom. Additionally, the importance of preparing students for future technological challenges will be considered. It will also examine the role of AR technologies in breaking down barriers in education, making learning more accessible to different groups of students, regardless of their location or access to expensive equipment.

Augmented Reality (AR) provides a unique opportunity to integrate virtual and real components, making it an ideal tool for teaching robotics based on Arduino modules or other programmable microcontrollers. AR technology is used to create virtual robot models, including detailed schematics of the components and elements of the Arduino system. This greatly increases the visibility and accessibility of the training, making it more attractive and understandable to students.

When using AR for creative robotics training and learning about circuits, connecting Arduino modules or other microcontrollers, and general schematization of components, students can visualize electrical circuits, observe them in 3D, and even interact with components by changing their location and connections in a virtual environment. This enriches the learning experience, making it more interactive and helping students grasp complex electronics concepts more easily.

Furthermore, augmented reality also allows the visualization of Arduino module schematics in 3D projections. Students can scan physical models of modules and see their virtual counterparts, with connections and components visually highlighted, making it very easy to understand the placement of components. For instance, students could take a real Arduino module, scan it with an AR device, and a virtual 3D model of that module would appear on the screen. They could then select sensors and actuators, scan them, and virtually connect them to the Arduino in a virtual environment. All of these features make learning more visual and help students master the complex aspects of Arduino circuits and connections with greater ease.

MATERIALS AND METHODS: Augmented Reality (AR) provides a unique opportunity to integrate virtual and real components, making it an ideal tool for teaching robotics based on Arduino modules or other programmable microcontrollers. AR technology is used to create virtual robot models, including detailed schematics of the components and elements of the Arduino system. This

greatly increases the visibility and accessibility of the training, making it more attractive and understandable to students. Most importantly, when using such creative robotics training and learning about circuits, connecting Arduino modules or other microcontrollers, and general schematization of components using augmented reality, students can visualize electrical circuits, observe them in 3D, and even interact with components by changing their location and connections in a virtual environment. This enriches the learning experience by making it more interactive and helps students grasp complex electronics concepts more easily.

Furthermore, augmented reality allows the schematics of Arduino modules to be visualized in 3D projections. Students could scan physical models of modules and see their virtual counterparts, with connections and components visually highlighted, making it very easy to understand which components go where. For example, students could take a real Arduino module, scan it with an AR device, and a virtual 3D model of that module would appear on the screen in front of them. They could then select some sensors and actuators, scan them, and virtually connect them to the Arduino in a virtual environment. All of this makes learning more visual and helps students master the complex aspects of Arduino circuits and connections more easily.

Various pedagogical methods can be used to teach robotics and microcontroller programming using AR technology, including:

- Problem-based method: Students are presented with real-world problems and challenges to solve through programming and working with robots. This method develops analytical and creative skills.

- Project-based learning: Students work on specific projects by building and programming robots. Projects can vary in complexity and subject matter, allowing students to put their knowledge into practice.

- Personalized learning: AR technology allows students to choose the level of difficulty and topics to explore according to their needs and abilities. Learning can be personalized for each student.

- Collaborative learning: Working in teams to complete projects and assignments. This develops skills in collaboration, communication, and shared responsibility.

- Independent study: Supporting students to conduct their own research in robotics and programming using AR technology.

This innovative approach to teaching robotics, based on Arduino modules and other programmable microcontrollers, significantly improves understanding of the material and promotes the development of students' creative, imaginative, and critical thinking.

The methodology highlights the effectiveness of Augmented Reality in the learning processes of design and programming educational contexts. AR improves student engagement by providing interactive and immersive learning experiences. In addition, AR-based instruction has been shown to be effective in improving understanding, retention and application of complex learning material. In ARDUINO programming and simulation, AR facilitates hands-on learning by allowing students to visualise abstract concepts and experiment with real-world applications.

The use of learning techniques can prepare students to solve complex technical problems, which has a significant impact on the development of modern education.

Outcomes: By learning robotics and microcontroller programming in the described methodology using augmented reality, students will achieve the following outcomes:

-Deep understanding of electronics and Arduino: They will acquire a deep theoretical understanding of electronic components, microcontroller principles and Arduino basics.

-Practical skills: Students will gain practical skills in assembling and programming devices based on Arduino and other microcontrollers. They will be able to successfully design and build robots and automated systems on a small scale, multi-project or smart home level.

-Ability to work with AR technology: You will have the skills to use Augmented Reality in teaching and designing electronics, which is useful in various fields where AR technology has found its application.

-Visualisation and modelling skills: thanks to 3D virtual environments, students will be able to visualise and model electronic circuits and components, which will help them save time and resources in real design.

-Creative thinking: Learning through AR and interactive tasks encourages creative thinking and the ability to apply knowledge to create new projects and solve real-world problems. Understanding the relationship between programming and hardware: Students have learnt to understand the relationship between programming and hardware, which enables them not only to create hardware devices, but also to program them to perform specific tasks.

Technical problem-solving skills: Students would become more confident in solving complex technical problems and be able to apply their skills and knowledge to real-world projects.

-Teamwork skills: Students working in teams on projects develop teamwork skills, which are important both in education and in today's robotics industry.
The skills and experience gained encourage students to pursue further study and research in the field of robotics and programming, because through the use of Augmented Reality and the methodology described, students gain not only theoretical knowledge, but also practical experience, which is invaluable for their future careers in various fields, particularly robotics and electronics.

These statistics confirm that the use of AR technologies in teaching robotics and microcontroller programming contributes to a significant improvement in students' learning outcomes and their preparation for future careers in the field.

DISCUSSION: Today's students are faced with rapidly changing technological challenges and tasks that

require them to be highly adaptable and capable of quickly learning new knowledge and skills. Incorporating AR technologies into robotics education is an important step in preparing students to successfully tackle complex technical challenges and innovative projects.

By using AR technology, students gain hands-on experience that is essential in today's world, where robotics and automation play a significant role in various industries such as medicine, automotive, manufacturing, and more. They learn how to program microcontrollers, design robots, and work with sensors, actuators, motors, drives, and other modules, which are crucial aspects in today's technological environment.

After considering the similarities and differences that may arise between the data learned and similar aspects in the field of robotics, it is important to evaluate the unique features and advantages of the tools used.

It is advisable to adapt the best teaching methods and techniques to the characteristics of the country. This approach will encourage students to be active during their studies and motivate them to learn independently, ultimately contributing to the improvement of national higher education.

The main problems in modern higher education include low student interest, insufficient supply of modern methodological materials and technical resources, and the qualification level of teachers. To address these issues, it is necessary to increase the number of specialized training programs to improve teachers' knowledge. In addition, teachers should be involved in cooperation with public and private companies and international organizations through grant programs. Furthermore, the practical implementation of some processes during practical training is often impossible due to their significant cost, time constraints, or health risks. AR technology is an effective tool that can help solve these problems.

There are several software learning environments and platforms directly related to the use of Augmented Reality (AR) in teaching robotics and Arduino microcontroller programming. Here are a few examples:

ARIS (Augmented Reality for Interactive Systems): ARIS is a platform for creating educational games and interactive tasks using augmented reality[1]. It allows students to create AR games and interact with virtual objects in the real world, which can be applied to teaching robotics and programming.

Vuforia: Vuforia is a popular SDK for creating AR applications[2]. It can be used to develop educational applications, including real-time simulations and visualizations, which are suitable for robotics education.

These and other software tools demonstrate the interest and potential of AR technologies in education. Many of them have similar aims to the methodology described for teaching robotics and microcontroller programming. Additionally, there are numerous educational materials and video tutorials available for learning the technology. AR constructors also enable the creation of necessary visualizations in a short time. The widespread availability of smartphones and tablets for most students facilitates learning with AR technologies.

CONCLUSION: The introduction of AR technologies in robotics education is an important step in the development of modern education. These technologies open up new horizons and redefine the way students learn and interact with software and hardware robotics based on Arduino modules and other programmable microcontrollers. Above all, students are no longer limited to static teaching materials and theoretical lectures. They can interact with virtual models, build and program robots, and explore concepts in a dynamic environment. This makes learning more engaging and allows students to learn by doing.

One of the directions of modern state policy in developed countries in the sphere of education is the improvement of the infrastructure of the information educational space. A necessary condition and priority for the development of the state education system is its digitalization. It is important to create appropriate IT resources for higher education institutions (HEIs). AR technologies have significant potential for implementation in the educational process, as the visualization of educational materials during classes allows for increased communication with students, enhances their activity, and contributes to better learning of the material. There is an urgent need for a comprehensive study of the possibilities of implementing AR technologies in higher education.

Modern students are oriented towards global trends, so educational institutions need to address the issue of innovation in the educational process. Thus, the application of the methodology based on AR technologies in teaching robotics, both using Arduino modules and any other microcontrollers, leads to significantly positive results. Students who learn with this methodology show a better understanding of the material, a greater interest in science and technology, and develop practical skills in robotics. Thanks to the visualization of circuits, interactive tasks, and the integration of virtual and real components, students can easily grasp complex concepts and apply them in practice. I believe that the introduction and development of AR technologies in education open up new perspectives for modern education and prepare future generations for the challenges of the modern world.

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