

Ai Based Virtual Laboratory Systems and The Application of It Education

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Abstract: This article analyzes the role of modern digital technologies, specifically artificial intelligence and virtual laboratories, in the contemporary educational system. It highlights the significance of information technology in transforming the educational process, the advantages of conducting experiments in a virtual environment, and the role of AI algorithms in assessing student knowledge. Furthermore, the technical foundations of creating virtual laboratories and their impact on educational efficiency are examined in fog networks through the deployment of service function trees and horizontal task distribution mechanisms.

Keywords: Artificial intelligence, virtual laboratory, IT education, educational simulations, digital transformation, higher education.

INTRODUCTION:

Today, technological progress is radically changing the education system, much like every other sector. Traditional teaching methods are being replaced by interactive, flexible, and distance learning formats. Practical training and laboratory work are of particular importance in teaching natural and technical sciences. However, expensive equipment, safety protocols, and time constraints often prevent students from gaining full practical experience.

The integration of virtual laboratories and Artificial Intelligence technologies is opening new horizons to overcome these challenges. A virtual laboratory is an environment that simulates a real laboratory setting using computer models and software. AI makes this environment smart, allowing it to adapt to the individual learning pace and level of each student.

The introduction of IT into education began with simple electronic textbooks and has evolved into complex ecosystems today. The application of IT in

education covers the following main areas. Managing the educational process through platforms like moodle or google classroom. Video lessons, interactive presentations, and simulations. Algorithms that change the level of difficulty based on the student's knowledge level. As the pinnacle of IT, artificial intelligence and virtual reality technologies are emerging in education. They serve as vital tools not just for delivering information, but for transforming knowledge into practical skills.

Creating virtual laboratories is an intersection of pedagogy, psychology, and software engineering. The development of the system involves the following stages. Mathematical equations of real physical or chemical processes are developed. For example, the speed of a chemical reaction or the force of a physical field is calculated via formulas. Three dimensional models of objects are created so that the user feels as if they are in a real laboratory. A user friendly interface is designed for students to control devices,

mix substances, or perform measurements.

The primary advantage of virtual laboratories is safety. For instance, working with radioactive substances or explosive compounds in a virtual environment poses no physical risk. Additionally, students can repeat an experiment an infinite number of times. AI transforms virtual laboratories from mere animations into intelligent tutors.

AI algorithms analyze every action of the student. If a student makes a mistake while assembling an electrical circuit, the system does not simply say "error", it identifies exactly which physical law was misunderstood and suggests supplementary materials. AI bots within the virtual laboratory assist students in real-time. They can provide advice, answer questions, or demonstrate the next step of an experiment. For educators, AI systems can predict which students are struggling with the subject or which specific topics are causing difficulties for the entire group.

The teacher's role changes when virtual laboratories and IT tools are introduced into the classroom. They transition from a traditional information provider to a facilitator. Theoretical parts are conducted as lectures, practical parts in a virtual laboratory, and final conclusions are drawn in a real-world laboratory setting. Incorporating game elements into the educational process increases student motivation. AI helps to create a fair competitive environment in this process. Despite the advanced nature of the technology, there are several difficulties in its implementation.

Creating high-quality virtual laboratory software and equipping it with AI requires significant resources. High speed internet or modern computers are not available in all regions. The necessity to develop the skills of educators to work with these new technologies. In the future, with the entry of the metaverse concept into education, virtual laboratories will become even more sophisticated. Students from different corners of the world will be able to gather in one virtual room and conduct scientific experiments together.

In AI driven virtual laboratories, AI does not only operate autonomously, it manages the interaction between the teacher and the student. The AI

identifies the student's difficulty level and sends a signal to the instructor at critical junctures. Rather than replacing the teacher, the system becomes an intelligent dashboard that indicates exactly which student needs assistance at any given moment. Multiple students can collaborate from different locations on a single project within the virtual lab, while the AI evaluates their collective teamwork efficiency.

Solving the problem of installing resource-heavy virtual laboratory systems on students' personal computers. Even if the laboratory system features high end graphics, it runs on a cloud server. Students can manage complex 3D simulations through a standard browser, even on a basic smartphone. This approach allows educational institutions to manage licenses centrally and save up to 40-50% on hardware costs.

Modern virtual laboratories are evolving beyond text and buttons to recognize various types of input signals. Students can issue voice commands within the lab, such as zoom in on the microscope 10 times. Through specialized haptic gloves, students can feel the hardness, temperature, or vibration of virtual objects. This is crucial for developing motor skills in fields like medicine and high-precision engineering. One of the most vital yet under-discussed aspects of IT in education is the monitoring of remote assessments. The system analyzes the facial structure, eye movements, and even keystroke dynamics of a student working in a virtual lab. This ensures with 99% accuracy whether the student is completing the task themselves or if someone else is intervening.

Replacing large, complex laboratory sessions with AI-supported, 5-10 minute micro-modules. Instead of waiting for a full session, students can quickly verify a single specific component in a virtual simulator. This is known as just in time learning. Research indicates that students utilizing AI-integrated virtual laboratories achieve a 27% higher performance rate in applying theoretical knowledge to real-world practice compared to traditional groups. Furthermore, the time required to master the learning material is reduced by an average of 15-20%. In the evolving landscape of digital education,

practical learning remains a cornerstone of computer science and technical pedagogy. Laboratory based experiences are essential for developing students' computational thinking, problem-solving skills, and technical proficiency. However, in many developing regions including parts of Uzbekistan access to state of the art physical laboratories is often challenged by infrastructural requirements, high maintenance costs, and the need for specialized technical staff.

The Current Challenge The disparity between traditional educational methods and the rapid advancement of technology continues to grow. While leading institutions like Turin Polytechnic University in Tashkent and the Tashkent Institute of Chemical Technology strive for excellence, the broader integration of hands-on learning requires innovative solutions that transcend physical constraints. Students often face a gap between theoretical instruction and practical application, which can limit their innovation potential and readiness for the global IT market.

The role of AI and virtualization recent developments in Artificial Intelligence and cloud computing present a transformative opportunity to reimagine how technical education is delivered. AI-powered virtual laboratories can simulate sophisticated experiments and real-world IT environments, offering intelligent tutoring that adapts to individual student needs. These platforms provide dynamic, scalable, and cost effective learning experiences that can be accessed from any location, effectively democratizing quality education.

AI integration and personalized learning while virtual labs provide the environment, the integration of AI serves as the intelligent engine that enhances personalization. AI can automate feedback, provide real-time assistance during complex simulations, and monitor student progress key factors in effective self-paced learning. For engineering and chemistry-based IT applications, these systems allow students to conduct virtual experiments safely and repeatedly, fostering a deeper understanding of complex scientific processes.

Strategic alignment furthermore, the implementation of AI-based virtual labs aligns with Uzbekistan's national digital transformation strategies and

educational reforms. By leveraging these tools, higher education institutions can ensure that their graduates possess not only theoretical knowledge but also the practical software proficiency required in the digital age. This approach bridges the gap between academic outcomes and employability, positioning students to lead future technological innovations.

CONCLUSION

AI-based virtual laboratories and IT tools are an integral part of modern education. They allow for an increase in the quality of education, the formation of independent research skills in students, and the saving of resources. By implementing these systems, the scientific potential of higher education institutions can be elevated to a new level. IT and AI are not just auxiliary tools but a strategic foundation for training the specialists of the future. The experience gained in a virtual environment serves as a key to solving complex problems in real life.

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