

ORGANIZATION OF CHEMISTRY LABORATORY ACTIVITIES BASED ON VIRTUAL REALITY (VR)

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Abstract: This article analyzes the theoretical and practical aspects of organizing chemistry laboratory activities based on virtual reality (VR) technologies. The study scientifically covers the impact of VR technologies on the educational process based on the theory of cognitive visualization and the immersive learning effect. It also examines the capabilities of Chemstr and other virtual laboratory programs, their role and effectiveness in teaching chemistry.

Keywords: Virtual Reality (VR), chemistry laboratory activities, immersive learning, cognitive visualization, virtual lab simulation, chemstr software, science education, experimental competence

Annotatsiya: Ushbu maqolada kimyo laboratoriya mashg'ulotlarini virtual reallik (VR) texnologiyalari asosida tashkil etishning nazariy hamda amaliy jihatlarini tahlil qilinadi. Tadqiqotda VR texnologiyalarining ta'lim jarayoniga ta'siri kognitiv vizualizatsiya nazariyasi hamda immersiv o'qitish effekti asosida ilmiy jihatdan yoritilgan. Shuningdek, Chemstr hamda boshqa virtual laboratoriya dasturlarining imkoniyatlari, ularning kimyo fanini o'qitishdagi o'rni va samaradorligi ilmiy jihatdan tahlil etilgan.

Kalit so'zlar: Virtual reallik (VR), kimyo laboratoriya mashg'ulotlari, immersiv o'qitish, kognitiv vizualizatsiya, virtual laboratoriya simulyatsiyasi, Chemstr dasturi, fan ta'limi, tajriba kompetensiyasi.

INTRODUCTION

One of the main problems in teaching chemistry is to bring abstract concepts (atom, molecule, bond, reaction mechanism) to the level of real perception. In traditional laboratory conditions, this process is limited, since many chemical phenomena occur at the microlevel and are not directly observed. Modern research shows that virtual reality (VR) technologies can solve this problem, allowing students to see and manipulate molecular-level processes in real time. Therefore, organizing chemistry laboratory classes based on VR is considered not only a pedagogical innovation, but also a tool for solving cognitive problems.

Theoretical foundations: cognitive and didactic effects of VR technology

1. Theoretical foundations of cognitive visualization:

Cognitive visualization theory is a scientific approach that aims to increase students' understanding of learning by presenting knowledge in a visual form. According to this theory, the human brain receives information through two main channels: visual (pictures) and verbal (text or oral).

This approach is closely related to the dual coding theory developed by Allan Paivio, according to which information is better understood when presented in both a visual and logical form.

This theory is especially important in teaching chemistry, since many chemical processes (molecular structure, electron clouds, reaction mechanisms) are abstract phenomena that cannot be directly observed. Virtual reality (VR) technology allows these abstract concepts to be represented through three-dimensional visual models.

In a VR environment, students; see the spatial structure of molecules, visually analyze the bonds between atoms, dynamically observe chemical reactions, and interactively control complex processes.

This activates the following cognitive processes in students.

Spatial thinking, analytical thinking, understanding cause-and-effect relationships, and strengthening long-term memory.

Also, according to the multimedia learning theory developed by Richard Mayer, the combination of visual and audio information helps students to assimilate knowledge more deeply. VR technology provides this integration. As a result, VR technologies based on the theory of cognitive visualization;

- concretize abstract concepts;
- systematically form knowledge;
- develop students' independent learning abilities.
- Sees molecules in 3D space
- Monitors reactions dynamically
- Transforms abstract formulas into visual models

This is explained by the “dual coding theory,” which means that knowledge is acquired in both a visual and logical form at the same time.

2. The result of immersive learning:

The immersive learning effect is the process of deep and sustainable assimilation of knowledge as a result of the student's complete "immersion" in the educational process. This approach is especially closely related to virtual reality (VR) technologies, which provide active learning by immersing the student in an artificially created environment.

During the immersion process, the student feels like he is working in a real laboratory. This leads to maximum concentration and full attention to the process being studied. As a result, passive learning turns into active learning.

Scientific studies show that learning in an immersive environment helps to maintain attention for a long time;

consolidates knowledge in long-term memory;

- increases learning motivation;
- significantly improves learning efficiency.

The main components of an immersive VR environment are:

1. Visual immersion - 3D graphics and realistic environment
2. Sensory immersion - tracking movements (hand tracking)
3. Cognitive immersion - the student's entry into the thought process
4. Emotional immersion - the emergence of a sense of interest and wonder

This process is explained by the theory of “Flow” developed by Mihaly Csikszentmihalyi. According to him, a person achieves maximum efficiency when he is completely immersed in an activity. VR creates this state in the educational process.

Immersive learning in chemistry education creates the following opportunities:

- performing dangerous experiments in a safe environment;
- observing complex reactions step by step;
- interactive work with laboratory equipment;
- conducting independent experiments.

In addition, in an immersive VR environment, students “learn by doing.” This is much more effective than traditional theoretical teaching.

Immersive technologies also develop the following competencies in students:

- problem solving;
- research skills;
- independent decision-making;
- practical thinking.

In conclusion, the immersive learning effect is one of the most important pedagogical advantages of VR technologies, which ensures the formation of deep and sustainable knowledge in teaching chemistry.

Virtual laboratory work, which is carried out using the **Meta Quest** device through the CHEMISTRY VR software, is carried out as follows.



Meta Quest 2



Meta Quest 3

Application of CHEMISTRY VR software



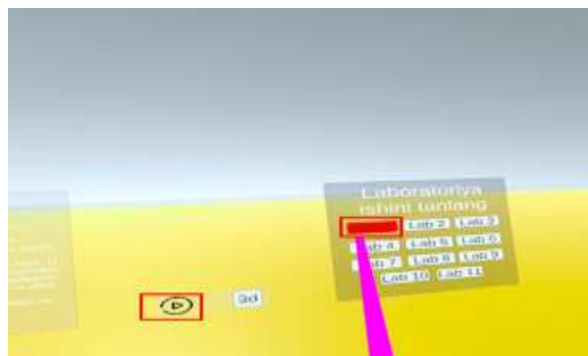
Meta Quest 2 provides the main part of the program



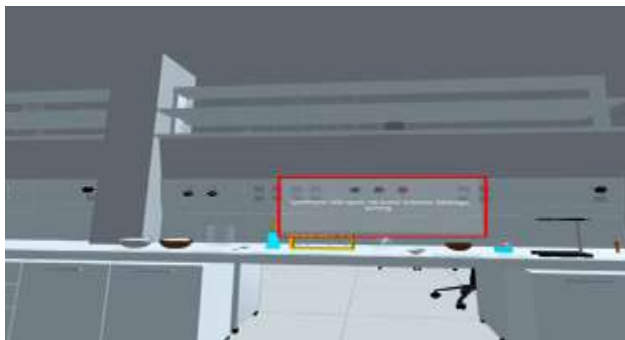
Go to the menu and find the CHEMISTRY VR program



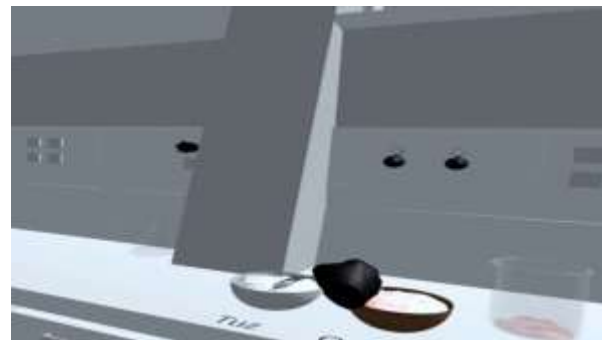
Introduction to Chemistry VR



In the right window, there is an opportunity to do laboratory work at 11, which is not a 7th grade textbook.

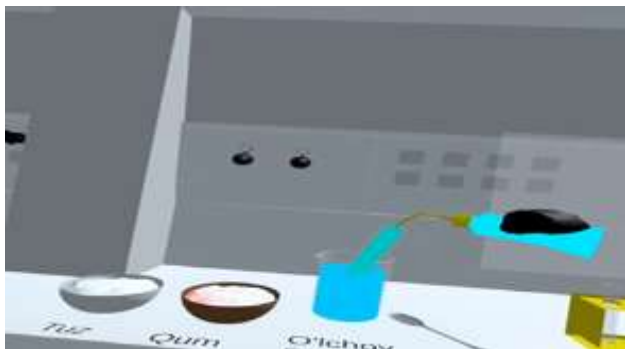


The interactive window will display the procedure for performing the laboratory work.

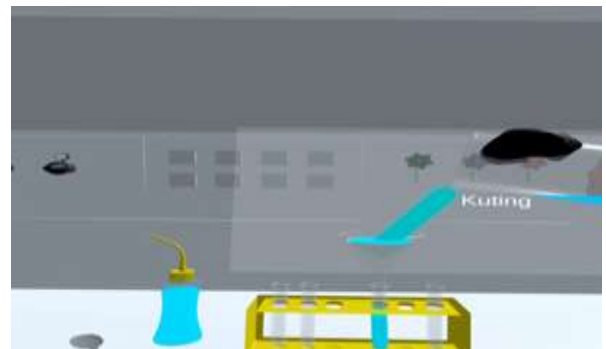


Lab 1: Purifying Mixtures.

Take a spoon and put the sand and salt into a measuring cup.



Pour water into a measuring cup and mix with a spoon to form a solution.



Pass the solution in the measuring cup through a paper filter.



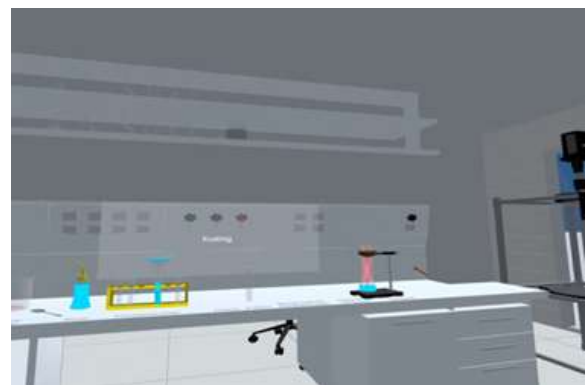
You are asked to pour the solution from the test tube into the evaporator dish.



Place the evaporator dish on the stand.



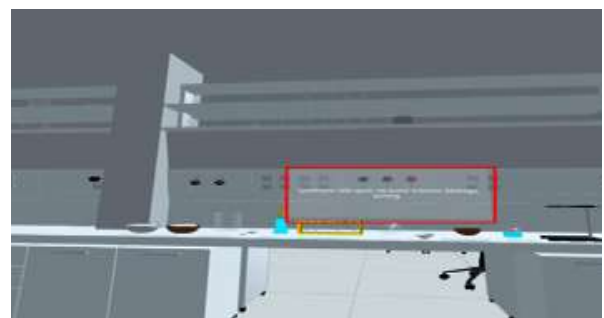
Turn on the alcohol lamp.



Process monitoring



After the water evaporates from the evaporator tank, you can observe that pure salt remains at the bottom of the tank.



You did the job correctly and accurately.

At this stage, students' readiness for innovative activities is developed and serves to reveal their innovative potential and develop an advanced level of scientific competence.

Advantages and scientifically proven advantages

VR laboratories have the following advantages:

- safety (no poisoning, explosion)
- economy (no reagents required)
- repeatability (unlimited experience)
- visual clarity
- possibility of distance learning

critical analysis

From a scientific point of view, VR is not a complete solution:

- does not fully reproduce real laboratory skills
- does not form enough “muscle memory” (practical reflexes) (Reddit discussions also noted this opinion)
- is dependent on technical resources

CONCLUSION

Organizing chemistry laboratory classes based on virtual reality is one of the most promising areas of modern education. In particular, virtual laboratories of the Chemstr type:

- develop students' scientific thinking
- help visually understand complex chemical processes
- create a safe and effective learning environment

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