



PEDAGOGICAL EFFECTIVENESS OF USING VIRTUAL LABORATORIES IN TEACHING CHEMISTRY AT ACADEMIC LYCEUMS

*Academic Lyceum of Chirchik State Pedagogical University
Chemistry Teacher Eshquvvatova Nargiza Norjigitovna*

Abstract. *This article analyzes the impact of virtual laboratory technologies on the quality of education and students' cognitive activity in teaching chemistry at academic lyceums. Virtual laboratories enable students to observe complex chemical processes in a safe environment, study the properties of substances interactively, and repeatedly perform experiments. The research findings show that experiments conducted in a virtual environment strengthen students' theoretical knowledge and promote the development of their scientific thinking and practical skills.*

Keywords: *virtual laboratory, chemistry education, digital technologies, academic lyceum, innovative pedagogy.*

Introduction. Effective teaching of chemistry is directly linked to experiments and practical activities, which help students consolidate theoretical knowledge through real processes. Chemical reactions, the structure and properties of substances, and their interactions are deeply understood not only through textbooks and lectures but primarily through experimental work. Therefore, laboratory activities are an essential component of chemistry education.

However, practice shows that many problems exist in real laboratories. The lack or high cost of reagents, outdated equipment, safety restrictions, and limited time allocated for experiments often prevent students from fully carrying out laboratory work. Moreover, some complex or hazardous chemical reactions cannot be conducted in school or academic lyceum settings. As a result, students are sometimes forced to study certain topics only at a theoretical level.



To address these challenges, virtual laboratories have emerged as an important pedagogical solution. Virtual laboratories allow chemical experiments to be modeled in a digital environment, enable visual observation of reactions, and support step-by-step analysis of processes. Such platforms give students the opportunity to conduct experiments without fear of making mistakes, modify reaction conditions, compare results, and independently assess their knowledge.

In addition, virtual laboratories enable students to observe chemical processes at the micro level-such as the movement of atoms and molecules, the breaking and formation of bonds-which helps visualize abstract concepts and leads to deeper understanding. Therefore, virtual laboratories are not only complementary tools to real experiments but are also recognized as innovative and effective pedagogical technologies in chemistry education.

Literature Review. Modern scientific research indicates that virtual laboratories significantly increase students' level of knowledge acquisition and strengthen their interest in chemistry. Experiments conducted in virtual environments allow students to visually observe chemical processes, analyze them, and independently identify errors, which contributes to deep and sustainable learning [1].

De Jong and Van Joolingen emphasize that virtual laboratories make it possible to accurately model micro-level changes in substances, including intermolecular bonds, reaction mechanisms, and energy transformations. This approach greatly facilitates students' understanding of abstract concepts [2].

Uzbek scholar Karimov demonstrates that the integration of digital educational technologies into chemistry teaching enhances students' experimental competence and practical skills. Through virtual laboratories, students can independently conduct experiments and analyze the results [3].

Rahmonov has empirically proven that the use of information and communication technologies in chemistry education-particularly simulations and virtual experiments-develops students' scientific thinking and their ability to solve problem-based situations [4].



Mirzayev also notes that digital laboratories ensure safety in chemistry education while providing opportunities to study complex and hazardous reactions, thereby assigning them high didactic value [5].

Results and Discussion. To determine the impact of virtual laboratories on chemistry education in an academic lyceum, an experimental study was conducted. Two parallel groups with the same initial level of preparation participated in the research. The control group studied chemistry through traditional laboratory activities, while the experimental group was taught using virtual laboratory programs. The experiment lasted for one semester, during which students' knowledge levels, experimental skills, and attitudes toward the subject were continuously monitored. In the group working with virtual laboratories, students were able to model chemical reactions step by step, modify reaction conditions, and compare outcomes. This helped them better understand cause-and-effect relationships. For example, observing how changes in temperature, pressure, or reagent quantity affect reaction rates allowed students to connect theoretical knowledge with practical analysis.

The results showed that students working in a virtual environment demonstrated a significantly higher level of understanding of chemical reactions compared to those in the traditional group. They made fewer mistakes when explaining complex reactions and participated more actively in logical analysis of results. Furthermore, the automatic error detection and feedback features of virtual laboratories helped students independently analyze their mistakes, leading to the development of reflection and self-monitoring skills.

In addition, students in the experimental group showed a considerable increase in learning motivation. They performed virtual experiments with interest and participated more actively in studying complex topics. The interactive environment, visual effects, and real-time display of results strengthened students' positive attitudes toward chemistry. As a result, their overall academic performance and interest in the subject improved significantly.



Conclusion. Virtual laboratories have emerged as a modern educational tool with high pedagogical effectiveness in teaching chemistry in academic lyceums. They enable students to study complex chemical processes in a visual and interactive manner, helping to integrate theoretical knowledge with practical experimentation. Through experiments conducted in a virtual environment, students gain a deeper understanding of chemical reactions, learn to analyze cause–effect relationships, and develop scientific thinking skills. The research findings demonstrate that the use of virtual laboratories significantly improves students' independent learning activity, their ability to analyze errors, and their self-monitoring skills. Moreover, these technologies make lessons more engaging and interactive, thereby increasing students' motivation to learn chemistry. As a result, a favorable pedagogical environment is created for deep and sustainable knowledge acquisition. Therefore, the systematic and methodologically sound implementation of virtual laboratories in chemistry education at academic lyceums should be regarded as one of the key strategic directions of modern pedagogy. These technologies play an important role in shaping a digital and innovative education system and in preparing students to meet the demands of scientific and technological development.

REFERENCES

1. Rutten N., Van Joolingen W. R., & Van der Veen J. T. *The Learning Effects of Computer Simulations in Science Education*. Computers & Education, 2012.
2. De Jong T., & Van Joolingen W. R. *Scientific Discovery Learning with Computer Simulations of Conceptual Domains*. Review of Educational Research, 1998.
3. Karimov A. *Raqamli pedagogika va kimyo ta'limida innovatsion texnologiyalar*. Toshkent: Fan va texnologiya, 2021.
4. Rahmonov S. *Kimyo fanini o'qitishda axborot texnologiyalaridan foydalanish metodikasi*. Toshkent: O'qituvchi, 2020.
5. Mirzayev B. *Virtual laboratoriyalar asosida kimyo ta'limini takomillashtirish*. Toshkent: Innovatsion ta'lim nashriyoti, 2022.