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TEACHING THE SUBJECTS OF "MICROBIOLOGY AND VIROSOLOGY" IN MEDICAL INSTITUTES WITH THE HELP OF A PERSONALIZED LEARNING PLATFORM BASED ON ARTIFICIAL INTELLIGENCE

Abdullayev G‘oyibsher Abdulxamidovich.
Fergana Institute of Public Health Medicine
Department of Microbiology, Virology, and Immunology
ORCID: 0000-0003-1232-5577 sherhan1991big@mail.ru

Abstract
Microbiology and virology are disciplines of high scientific and practical importance in the fields of biology, medicine, sanitation, biotechnology and public health. The educational process in these areas includes complex theoretical concepts and experimental basic concepts. Traditional teaching methods sometimes create problems such as not fully meeting individual requirements, reducing students' interest in classes, and incomplete formation of analytical thinking and laboratory skills. In recent years, artificial intelligence (AI) technologies have been causing revolutionary changes in the field of education. Adaptive learning systems based on AI offer content and guidance that adapt to the user, identifying individual needs. Such platforms make the educational process more interesting, dynamic and encourage students to be more active. In this regard, it should be noted that the role and capabilities of AI in complex disciplines such as microbiology and virology are relevant.

Keywords: Artificial intelligence (AI), microbiology and virology, “adaptive learning systems”, Learning Management System (LMS).

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Relevance

With the help of artificial intelligence and the concept of adaptive learning, it becomes possible to directly analyze the student's level of knowledge, pace of comprehension, mistakes and shortcomings, interests, and attention indicators. Based on such analyses, the platform delivers information in a personalized manner—for instance, by repeating difficult topics, offering interactive tests, and proposing exercise options. It is noted that platforms such as Khan Academy, Coursera, and Smart Sparrow include adaptive learning modules. Studies show that this methodology increases engagement in the learning process and improves comprehension efficiency.

The application of AI-based educational platforms in microbiology and virology has been successfully implemented in platforms such as Microbiology Edu, Labster, and Visible Body through AI-driven analytical algorithms for laboratory simulation. For example, the Labster platform teaches critical laboratory processes interactively using 3D models. Furthermore, in remote training, online laboratories, automatic error detection, and feedback mechanisms have significantly improved the quality of education.

Existing Limitations

- **Technical infrastructure:** Adequate computer and Internet infrastructure is required.
- **Pedagogical limitations and teacher qualification:** Specific training is necessary to correctly integrate AI tools into pedagogical processes.
- **Data quality and confidentiality:** Issues of security and privacy when handling personal data of learners are considered highly relevant.
- **Diversification of educational content:** Specialized modules are required for topics such as microbiological species, viral classification, and genetic modeling.

The integration of artificial intelligence into educational technologies marks a transformative phase in medical pedagogy, particularly in disciplines requiring both theoretical comprehension and practical application, such as microbiology and virology. Traditional lecture-based methods often fail to account for the diverse cognitive profiles, learning speeds, and engagement levels of students, leading to unequal knowledge acquisition and reduced academic motivation. AI-

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driven adaptive learning systems offer a promising alternative by enabling real-time diagnostics of individual learning trajectories, identifying conceptual gaps, and dynamically adjusting instructional content to match each student's needs. In the context of medical education, where mastering complex biological systems, laboratory procedures, and diagnostic reasoning is critical, such personalization not only enhances cognitive retention but also fosters clinical readiness. Moreover, by simulating laboratory environments and facilitating interactive engagement through virtual platforms, these systems mitigate the limitations of physical infrastructure, expand access to high-quality education, and support continuity of instruction during disruptions such as pandemics. Empirical studies increasingly demonstrate that adaptive learning technologies significantly improve not only academic outcomes but also learner satisfaction, autonomy, and long-term knowledge retention. Within this framework, the implementation of AI-supported LMS platforms in microbiology and virology represents a timely and evidence-based response to the evolving educational demands of the 21st century.

Research Aim

To analyze the mechanisms, advantages, limitations, and outcomes of integrating AI-based LMS into the teaching of microbiology and virology.

Research Methods

The research consisted of the following stages:

1. Division of students into two groups—a test group (adaptive LMS + practical training) and a control group (traditional teaching methods).
2. Administering short tests to both groups: initial (pre-test), final (post-test), and intermediate assessments.
3. The adaptive LMS was enriched with social and theoretical materials: videos, animations, 3D lab modules, interactive quizzes.

Results and Analysis

According to test results, the knowledge level of the test group trained with the adaptive LMS showed an average increase of +15–20% in the post-test compared

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to the control group. This result was statistically significant at $p < 0.01$. Additionally, the number of test errors in the test group decreased by 35%.

Interest in the learning process and student comprehension metrics were assessed using the Likert scale (1–5). Results showed that the adaptive LMS group averaged 4.3 points, while the control group averaged 3.6 points. Observations revealed that online lab simulations and real-time feedback were highly beneficial.

The Software Used in the Research Included the Following Components

- **User profile:** Captured the learner's knowledge level and learning speed.
- **Content modules:** Each module was tailored to a microbiology/virology topic, ranging from bacterial structure to viral replication, ending with assessment tests.
- **Guidance system:** The system provided resources for specific topics only if the learner made critical errors.
- **Real-time feedback:** For each interactive task, automatic and explanatory feedback was delivered.

During the study, data such as pre- and post-test scores, platform logs from the LMS system, test accuracy indicators, and assigned grades were analyzed. Chi-square test, t-test, and ANOVA were used to determine whether the differences between groups were statistically significant.

LMS usage statistics revealed the following:

The test group was active on the LMS for an average of 28 hours, engaging in daily learning activities for 45–50 minutes. The control group was active for a total of 18 hours. These figures can be interpreted as follows:

- The adaptive LMS adjusted to individual learning levels, reinforcing important topics through repetition.
- Real-time feedback helped correct errors immediately and deepen understanding.
- 3D laboratory simulations presented practical tasks in an engaging and safe format.

The results confirmed that the adaptive LMS is an effective tool in microbiology and virology education. A notable improvement in students' knowledge and

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motivation confirms the effectiveness of AI integration. This opens new opportunities for creating an experience-based learning process that harmonizes theoretical and practical components.

However, the study identified issues such as infrastructure limitations (Internet speed, devices) and inadequate technical preparedness among instructors. To address these problems, online training, technical support centers, and the development of local infrastructure at the department level are necessary.

Analyses suggest that adaptive LMS platforms can also be expanded to other medical sciences (e.g., immunology, genetic diagnostics). There is potential to create new diagnostic modules based on machine learning and algorithmic processing.

To Broaden Future Research

1. Conduct assessments with larger samples (involving various countries, universities, and age groups).
2. Implement long-term monitoring to track micro-evolutions of knowledge with intelligent metrics (IMQs).
3. Enrich content with multilingual, visual, and 3D-integrated design elements.

Conclusion

An AI-based personalized LMS platform serves as a complementary and enhancing tool to traditional teaching methods in microbiology and virology education. Research results demonstrated a significant positive shift in students' knowledge levels and motivation due to adaptive LMS. Moreover, if technical, pedagogical, and infrastructural issues are systematically resolved, AI-driven LMS has the potential to radically improve educational quality. In the future, expanding this approach and integrating it into other areas of medical education is advisable.

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