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Improving The Didactic Support Of The Methodology For Teaching General Microbiology In Higher Education Institutions

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Abstract: This paper involves the issues of improving the didactic support of the methodology for teaching general microbiology in higher education institutions. The importance of didactic principles, innovative pedagogical technologies, simulation methods, and didactic games in the educational process is substantiated. The paper analyzes ways to integrate theoretical knowledge with practical training in teaching microbiology, immunology, and virology, as well as methods for activating students' cognitive activity and developing their creative and critical thinking skills. In addition, the relevance of virology education under the conditions of the COVID-19 pandemic, approaches to active learning based on Bloom's taxonomy, and the potential of virtual simulation and distance learning technologies are discussed. The effectiveness of using didactic games to develop students' knowledge, skills, and competencies is also justified.

Keywords: Didactics, microbiology, virology, teaching methodology, didactic principles, didactic games, simulation games, Bloom's taxonomy, educational technologies, virtual simulation, distance education, innovative pedagogy.

Introduction: Didactics is a scientific field aimed at the effective organization of the educational process, and its main purpose is to enhance the effectiveness of teaching and learning activities of teachers and students. Didactic principles of teaching form the foundation for organizing the educational process, and their correct selection and application play a significant role in raising students' knowledge and skills to a higher level. In every teaching process, there is a need to develop and apply didactic principles, as they determine the methodological, psychological, and pedagogical approaches necessary to achieve the goals of the education system. Didactic principles are the fundamental components that structure the teaching process. Through them, the goals, content, methods, tools, and outcomes of education are interconnected. When developing and applying these principles, it is especially important to consider modern teaching methods and pedagogical innovations that meet the requirements of contemporary education systems. At the same time, didactic principles require teachers to take into account students' psychological characteristics, learning needs, and individual differences in their professional practice [3; pp. 372–376].

RESULTS

In practical classes on microbiology and immunology, simulation games are widely used. At the planning stage of a simulation game, the teacher identifies the problem, determines possible solutions, develops the scenario, and assigns specific roles to students. In simulation games devoted to the microbiological diagnosis of infectious diseases, students play the roles of patients, relatives, emergency physicians, admission department staff, laboratory assistants and bacteriologists, epidemiologists, and others. The scenario reflects the characteristics of the situation, the composition of participants' roles, locations, and the documents used (forms derived from microbiological tests and response methods) [9; pp. 8–10].

In teaching biology, role-playing and business games aimed at effectively integrating theoretical knowledge with its practical application are often used. These games create tense and conflict-based situations that force participants to make specific decisions under conditions of time pressure, incomplete information, and opposition from other players. Participation in research activities is more important for developing students' creative abilities than the final result of their activity. Games encourage students to generate original ideas and make creative decisions, sometimes leading to conflicts of viewpoints and the need to defend one's position. Thus, didactic games contribute significantly to the development of creative thinking. Several psychological principles support the stimulation of students' creative behavior during games. A friendly, creative, and supportive classroom environment is crucial. Teachers should model creativity, avoid excessive criticism of creative work, encourage originality, and strive to foster brainstorming activities [7; pp. 702–707].

Any technology developed in didactics serves to activate students' cognitive activity and increase educational effectiveness. However, in the following technologies this objective constitutes the core idea:

- didactic game technologies;
- problem-based learning technologies;
- thematic learning technologies;
- cooperative learning technologies;
- project-based learning technologies.

Along with their specific characteristics, these technologies perform educational, developmental, and formative functions; guide creative activity; develop communicative and logical thinking skills; form methods of intellectual activity; teach self-analysis, career orientation, correct goal-setting, and cooperation within the educational process [11; pp. 177–185].

Introducing students to microbiology during their education helps generate interest and excitement in this field. However, at the undergraduate level, many students have little exposure to virology, even within microbiology courses. Virology instructors should support undergraduate teachers who may have limited expertise in virology. Challenges in virology education exist not only at the undergraduate level but also at the master's level.

Did the COVID-19 Pandemic Increase Interest in Teaching Virology?

Many faculty members responded to the question of whether the COVID-19 pandemic increased interest in teaching virology. In the spring of 2020, several instructors teaching microbiology incorporated real-time content to help students understand and contextualize aspects of the coronavirus pandemic. Others noted that instead of using hypothetical examples such as "Virus X," they used Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). Some faculty members were not teaching microbiology during the spring of 2020, but most believed they would include SARS-CoV-2/COVID-19 content in future courses.

Some instructors reported that the pandemic led them (and/or their departments) to consider offering a full course in virology. Importantly, several faculty members chose not to include such content due to the personal impact of COVID-19 on students and the potential discomfort associated with the topic. While it is important to consider the presence of virology in undergraduate curricula, instructors must determine what content their students truly need. Given the limited time available in undergraduate programs, understanding concepts and their application is more important than simply conveying large volumes of facts.

Bloom's taxonomy is particularly useful in this context. For those unfamiliar with Bloom's taxonomy, it proposes six levels of learning: remembering, understanding, applying, analyzing, evaluating, and creating. The first three levels form the foundation for deeper learning, enabling students to analyze, evaluate, and create. Although a detailed discussion of Bloom's taxonomy is beyond the scope of this paper, it is important to balance content and application so that students can apply their knowledge in relevant future contexts. Therefore, the examples discussed above emphasize active learning rather than rote memorization. This approach provides undergraduates with a foundation for learning how to learn independently, which is crucial given their limited exposure to virology content.

Students should study virology modules carefully; however, minimal virology content and standalone virology courses are not always available. Even at the master's level, opportunities for in-depth virology education are limited. Virology education has become more important than ever, prompting groups of virology educators to raise questions about what virology content should be included in undergraduate microbiology courses and what students should learn if they are to acquire virology knowledge. The time has come for a deeper understanding of viruses. Coordinating these efforts with initiatives to revise virology education at the master's level can enhance general awareness and streamline the dual goals of educating future virology instructors and researchers [2; pp. 13–27].

Microbiology and immunology are rarely integrated, and lessons often neglect the true meaning of hygiene rules. In our view, the importance of microorganisms in human life and ecosystems, though capable of stimulating interest in science, is often overlooked. Invisible organisms can be fascinating for students, and invisibility does not equate to incomprehensibility. With appropriate methods and an adequate level of content organization, virtually anything can be taught (Vygotsky, 1934; Padoa Schioppa, 2014; Santovito, 2015; Pluviano & Della Sala, 2020).

According to researchers, cognitive, behavioral, and attitudinal objectives are essential in teaching microbiology and virology. Data collected through self-assessment and activity-based reflections, as well as measures aimed at engaging students with disabilities or cognitive and linguistic difficulties, confirm the effectiveness of the proposed approaches. These results also address concerns raised in online surveys of teachers and parents, many of whom worry that topics may be misunderstood or perceived as frightening. Others believe certain activities may be unsafe or difficult to implement without specialized and costly equipment. As part of didactic research, many factors may influence outcomes [1; pp. 92–101].

Several key positions regarding microbiology education are highlighted:

- microbiology should be deeply integrated into school curricula;
- general biology textbooks should be organized around a microbiological core;
- all life science students should receive microbiology education as part of their core curriculum.

Developing students' understanding of microbes ultimately increases public awareness of the importance of microorganisms for everyday human and planetary health.

Currently, educational technologies are widely used across academic disciplines. Initially implemented to achieve more effective teaching and active learning, they have evolved to become potential substitutes for face-to-face instruction, contributing to pedagogical development, increased interactivity, and expanded learning opportunities. However, the belief that technology alone can solve complex educational problems represents an overly simplistic form of technological determinism (Grainger et al., 2020). In addition to confusion between "information" and "knowledge," many studies on technological solutions in education show no significant differences in outcomes. The COVID-19 lockdown revealed the limitations and shortcomings of exclusively online teaching methodologies [6; pp. 665–670].

Virtual simulation experiments involve the use of computer software and hardware to replicate real experimental environments, enabling users to perform realistic operations in virtual settings. Such experimental projects are essential for applying virtual reality technologies to research and education. Medical microbiology experiments integrate theoretical knowledge and operational skills, fostering comprehensive experimental abilities, scientific thinking, and innovation. While traditional experimental training develops practical skills, it is limited by factors such as laboratory space, costs, ethical constraints involving experimental animals, and students' lack of prior experience. Virtual simulation platforms allow repeated practice in a safe environment and facilitate the integration of experimental learning content. Large-scale comprehensive virtual experiments enable students to design and manage experiments, analyze results, and draw conclusions, thereby expanding learning content and professional perspectives [5; pp. 617–621].

Distance education, e-learning, and online learning are often used interchangeably, though they are not clearly defined. According to the Merriam-Webster dictionary, learning is the act of acquiring knowledge, while education refers to the process of teaching specific knowledge or skills in educational institutions. Distance education has a long history, previously relying on postal services to reach remote areas; today, materials are delivered through the internet using videos, synchronous and asynchronous interactions, and digital resources.

There is no doubt that modern tools have dramatically changed how we teach, learn, and communicate. These tools are increasingly applied in microbiology. Technological advancements are revolutionizing the field: automation, mass spectrometry, and bacterial fingerprinting are replacing traditional culture plates. Electronic tools will be essential for communicating new discoveries and teaching the transition from classical to modern microbiology. We must remain open-minded, as only the future will determine what we teach and which digital tools we use [4; pp. 1203–1207].

According to E. I. Soveiko, didactic games can be diverse, targeting various forms of teacher and student activities and applied across different disciplines. Their development is based on teachers' creativity and personal perspectives regarding the use of specific games for particular topics. In practice, various methodological games are used to foster creativity, including "Associations," "Understand Me," "Alphabet," "Ten Differences," puzzle games, and "I Am an Artist," each designed to reinforce knowledge, enhance critical thinking, encourage collaboration, and stimulate students' imagination [10].

Intensifying professional training is a promising direction for developing methodologies for teaching microbiology. Successfully implementing such strategies requires scientifically grounded methods for managing cognitive processes that mobilize individual creativity. Acmeological, game-based, and information technologies significantly enhance lesson effectiveness and reduce instructional time when applied comprehensively. Only an integrated approach can lead to genuine success in improving the quality and effectiveness of microbiology education [8; pp. 25–27].

CONCLUSION

In conclusion, effective teaching of general microbiology in higher education institutions requires the systematic improvement of didactic support. The integrated use of didactic games, problem-based and project-based learning, collaborative teaching, and virtual simulation technologies enhances students' cognitive activity and ensures a close connection between theoretical knowledge and practical application. The relevance of virology education has further increased under pandemic conditions, contributing to the development of students' awareness of healthcare, hygiene, and scientific thinking. Applying active learning approaches based on Bloom's taxonomy in the educational process promotes students' independent thinking and creative potential. Overall, the integrated use of didactic, game-based, and information technologies is an important factor in improving the quality of microbiology education.

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