UDC 615.07:378.147
DOI https://doi.org/10.32782/health-2025.1.28

VISUALIZATION OF KNOWLEDGE: THE ROLE OF VIDEO FORMATS IN TEACHING CHEMICAL DISCIPLINES TO FUTURE DOCTORS

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The integration of video lesson formats in teaching chemical subjects to learners in medicine and its bearing on the quality of learning is the focus of this article. The paper rests on scientific literature, practical teachings, and students' testing scores. It discusses the methods and techniques used in video lessons and offers recommendations for maximizing the use of video materials in the instructional process in order to increase students' motivation as well as academic achievement. The results of the research indicated that video content broadened the scope of assistance offered in the teaching of chemistry subjects to medical university students. Students appreciated the chance to learn complex topics through the use of experimentation and virtual reality. YouTube and Microsoft Teams allow easy access to materials and their use in independent learning. In addition, the survey showed that there is a notable need for supplemental videos for students' preparation for practical work.

Using a variety of video materials creates interest in students and enhances their academic achievement. It has been established that students learn best when they participate in interactive educational activities, such as digital laboratory experiments presented in the form of videos helps enhancing their analytical skills and deepening their comprehension of the practical aspects of chemistry. The use of video materials also simplifies instructors' preparation for practical lessons in a distance learning format. Additionally, the study highlights the importance of interactive elements in video content, such as quizzes and annotations, which further engage students and reinforce key concepts.

Further integration of technology into the educational process will enable the development of even more effective approaches to distance learning, which is especially crucial in the face of modern challenges, including martial law and the increasing demand for flexible learning solutions. The study concludes that a blended approach, combining traditional teaching methods with innovative video-based tools, can significantly enhance the overall educational experience for medical students.

Key words: *video content, chemical disciplines, learning effectiveness, experiment visualization, educational technologies, resource integration, distance learning, student engagement.*

Поліна Коломієць, Алла Грекова, Яніна Бурдіна, Реда Аббассі. Візуалізація знань: роль відеоформатів у викладанні хімічних дисциплін для майбутніх лікарів

Стаття присвячена дослідженню ефективності використання відео-форматів у викладанні хімічних дисциплін для здобувачів освіти медичних університетів та їх впливу на якість засвоєння матеріалу. Дослідження базується на аналізі наукових джерел і педагогічного досвіду, а також результатах тестування студентів. У роботі розглядаються методичні та технічні аспекти впровадження відео-уроків, а також надаються практичні рекомендації щодо оптимізації використання відео-контенту у навчальному процесі для підвищення мотивації та успішності студентів. Отримані практичні результати свідчать про високу ефективність використання відео-контенту як допоміжного інструменту в навчанні хімічних дисциплін для студентів медичного університету. Студенти позитивно оцінили можливість повторного перегляду матеріалів та покращення розу-

міння складних тем завдяки візуалізації експериментів. Використання платформ YouTube та Microsoft Teams сприяє зручному доступу до навчальних ресурсів і їхньої інтеграції в самостійне навчання. Крім того, аналіз опитувань виявив значний попит на додаткові відео-матеріали, особливо для підготовки до практичних занять.

Впроваджено різноманітній відео-контент, який підвищує зацікавленість студентів і сприяє кращому засвоєнню навчального матеріалу. Доведено, що цифрові лабораторні роботи у форматі відео дозволяють студентам детально ознайомитися з експериментами, що сприяє розвитку їхніх аналітичних навичок та глибшому розумінню практичних аспектів хімії. Застосування відеоматеріалів також спрощує підготовку викладачів до практичних занять у форматі дистанційного навчання. Подальше впровадження технологій в освітній процес дозволить створити ще ефективніші підходи до дистанційного навчання, що є важливим в умовах сучасних викликів, зокрема під час воєнного стану.

Ключові слова: *відео-контент, хімічні дисципліни, ефективність навчання, візуалізація експериментів, освітні технології, інтеграція ресурсів.*

Introduction. The need to acquire knowledge through the latest online tools–simulations, videos, virtual whiteboards, interactive platforms, resources, games, etc. has been evident for decades. The emergence of the Internet and the expansion of high-quality online services have shifted education away from its traditional roots and conventional methods toward distance learning and the adoption of an online culture. Today, most educational institutions, from schools to research institutes, utilize modern platforms and services. These tools do not replace traditional teaching methods but rather complement them as a means of improvement.

Tectonic shifts in social and economic conditions create unpredictable events that stimulate extensive research and new ideas. Due to the COVID-19 pandemic, educational trends have shifted from conservative teaching methods to online education, with the emergence of innovative platforms and teaching methods. In the context of a full-scale war, Ukrainian society must continue to receive quality education to remain competitive in the job market despite difficult circumstances.

Relevance of the Topic. The development of medicine occurs in two key areas: medical education and healthcare. Medical education is a rapidly evolving field that requires the latest technologies due to changing trends in clinical practice for diagnosing and treating various diseases. It involves not only training medical students but also the continuous professional development of practicing specialists. Modern approaches include the use of simulations, virtual reality, and interactive learning platforms, which allow students and doctors to practice their skills in a safe environment. Such methods contribute to better learning and increased competence.

Healthcare, as another area, includes the organization of medical services, disease prevention, and the provision of high-quality patient care. In this context, information technology plays a crucial role, as it improves the management of medical institutions, enhances diagnosis and treatment through the analysis of large datasets, and enables remote monitoring of patients' health.

Objective. This study aims to evaluate the effectiveness of video formats in teaching chemical disciplines to medical university students and their impact on learning quality. The paper discusses the methodological and technical aspects of implementing video lessons and provides practical recommendations for optimizing the use of video content to enhance student motivation and academic performance. Additionally, student testing was conducted to evaluate the efficiency of this approach, with results that allowed us to draw conclusions about key factors influencing learning quality and opportunities for further curriculum enhancement.

The research methodology includes the analysis and synthesis of scientific sources, pedagogical experience, interpretation of results, and practical recommendations.

The scientific novelty of the study lies in identifying the importance of video content for first– and second-year medical students and establishing norms and principles for pedagogical online communication during video conferencing.

With the outbreak of hostilities, higher education institutions had to introduce significant changes to the structure of the educational process, transferring some lectures and practical classes to a distance-learning format. Each institution determined teaching methods and class schedules independently, considering location and proximity to combat zones. The educational process underwent transformation, and medical students faced significant difficulties adapting to distance learning under martial law [1]. Studies [2] associate these new conditions with increased exhaustion, stress, and other psychological and physical burdens that affect the quality of life and daily activities of medical students. Such manifestations of depression, anxiety, and stress contribute to the development of post-traumatic stress disorder and professional burnout among students.

At the same time, traditional teaching methods based on the teacher's explanatory approach (narra-

tion, demonstrations, lectures) and students' reproductive activities also require reconsideration. Since knowledge is transmitted in a "constructed" form, students rely mostly on associative memory. For many years, the primary "practical" methods have included lectures, lecture-demonstrations, laboratory (visual) methods, project-based learning, group projects, and discussions [3]. The chemical disciplines taught at Odesa National Medical University include medicinal chemistry, bioorganic chemistry, biological chemistry, applied chemistry in medicine, physical and colloidal chemistry, pharmacology, and other related sciences. These methods are convenient and effective when implemented using appropriate pedagogical techniques and well-structured educational planning. However, the world is changing, and traditional methods alone are no longer sufficient to improve the quality of the educational process. The pandemic and martial law in Ukraine have particularly highlighted the vulnerabilities of the traditional education system.

The formation of cognitive interest in students is of fundamental importance for the conscious assimilation of chemical disciplines and should be directed toward fostering their exploratory and creative activities. Psychologists emphasize the procedural characteristics of creative activity, arguing that students cannot be taught solely by transferring ready-made knowledge and demonstrating methods of action. These skills can only be acquired through direct engagement in activities that involve working within a problem-based learning framework. A vast body of research has been devoted to problem-based learning. However, many questions remain unanswered, but modern technologies facilitate the integration of the best scientific teaching methods and their implementation in contemporary educational settings [4].

Thanks to computerization, a fundamentally new learning format has emerged – distance learning. This is a set of educational services delivered through specialized information and educational environments using telecommunications. Such learning offers several advantages over traditional teaching methods, including the ability to acquire new knowledge conveniently without interrupting primary activities, rapid information updates, reduced training costs, objective assessment, and more. Distance learning is now an integral part of the modern higher education system. It does not contradict the existing face-to-face learning model but rather integrates naturally with traditional systems to enhance and develop them.

Today's students prefer to receive and process information in a dynamic and interactive format, including 3D models, simulations, quests, interactive exercises, didactic games, and puzzles. Therefore, incorporating elements of advanced digital technologies into education is essential for increasing motivation, fostering independent learning, and bridging the gap between theory and practice. These resources are valuable as they are more engaging, interactive, and innovative compared to traditional textbooks. Moreover, the personalization of e-learning systems is a key advantage highlighted in recent research, allowing educators to select parameters and flexibly combine them to create tailored learning strategies based on course specifics.

Modern education is undergoing a process of global informatization and digitalization [5; 6]. It is characterized by the rapid advancement of digital technologies, electronic information resources, augmented and virtual reality technologies, and online services for creating various tests, quizzes, didactic games, puzzles, crosswords, word clouds, and mind maps.

Digital tools (online resources and services) refer to software applications accessible via the Internet at any time. Their use in the classroom helps educators better understand students, assess their abilities and knowledge, and adopt an individualized approach when selecting new teaching methods. This facilitates learner-centered education, where the focus is on the student, and the primary activity is cognitive rather than instructional. The teacher assumes the role of an organizer and facilitator of students' independent cognitive activities. As a result, the educational process fosters dialogue rather than monologue, as seen in traditional education. The shift from a "reproductive" to a "creative" learning approach is driven by the interaction between participants in the educational process and modern technologies. For teachers, mastering digital tools is an ongoing journey of self-improvement, lifelong learning, and professional growth.

An example of such digital technologies is any resource that enables the creation, editing, storage, transmission, and reception of information in digital form [5]. For instance, the Go-Lab platform is a free tool for modern education that allows teachers to demonstrate experiments while explaining the material and students to conduct online research in a virtual laboratory. This platform helps students develop essential scientific research skills, including planning and conducting experiments, defining objectives, selecting appropriate methods and tools, critically evaluating information in chemistry, and formulating conclusions. Such interactive platforms, which can function as online services or standalone applications, are becoming increasingly popular. Below are exam-

ples of what we consider to be the best online laboratories: ChemCollective (https://chemcollective.org/), Virtual Labs (https://www.vlab.co.in/broad-area-chemical-sciences), Labster (https://www.labster.com/), PraxiLabs (https://praxilabs.com/en/request-free-demo), Go-Lab (https://www.golabz.eu/).

Contemporary scholars, such as Mark Prensky [7], Snjala Y. [5], writer Nicholas Carr [8], and even businessman Don Tapscott, refer to the current generation as the "digital generation" or "digital natives" because these individuals were born in the digital age, where digital technologies have been an integral part of their lives since childhood. However, the ease of access to advanced digital tools has made it more challenging for them to maintain concentration, leading to behavioral changes that, in turn, affect academic performance. A traditional classroom has transformed into an online conference, where direct interaction between participants is absent, and teachers are compelled to radically modify their teaching methods, reorganize practical work and group interactions among students, and adopt new approaches to providing feedback. Additionally, an entirely new domain of etiquette has emerged, playing an equally significant role in structuring and mastering educational material. This highlights the necessity for all participants in the educational process to develop specialized digital communication skills and establish new norms and rules for interaction in the digital environment.

This article substantiates the importance of digital etiquette not only for educators but for all participants in online communication, as it directly impacts the effectiveness of the entire pedagogical process [9].

Ukrainian researchers have identified eight principles that form the foundation of digital etiquette: demonstration of a positive attitude, adherence to subordination, symmetry, respect for personal boundaries, convenience, resource conservation, tradition, and principles of convention and safety [10–13]. Those engaged in online education are well aware of both the advantages and disadvantages of digital communication. However, according to the authors [9], achieving high results in online learning and communication is only possible through the responsible self-organization of each participant. To be an effective online colleague, one must: choose the appropriate method of communication and understand the technical capabilities of the selected service; prepare in advance for online events; respect the time and space of all participants; and be attentive.

Preparation for a videoconference is crucial, including: checking technical readiness (setting up an internet connection, ensuring equipment functionality, checking the camera and microphone, proper lighting for the face, installing and testing the video communication service); physically preparing (appropriate appearance, neutral background, quiet environment, comfortable workspace, glass of water); psychologically preparing (readiness for active interaction, neck and limb warm-up, punctuality); and preparing necessary materials for the session.

During the video conference, you should immediately establish rules for participants: sign your account with your name and surname and set a real photo; connect on time and respect the time of others; keep the camera on; turn on the microphone only during your turn to speak; do not interrupt the speaker, ask questions in the chat or after receiving permission; adhere to etiquette rules (do not argue, do not shout, do not engage in unrelated activities); adhere to the online dress code; be an attentive and active participant.

One of the extremely interesting and effective tools for learning, in our opinion, is a variety of video materials, such as video lectures, video laboratory work, and other types of educational videos. They facilitate conceptual understanding and help students learn effectively by clearly demonstrating aspects of different concepts, which are useful for grasping basic ideas and reinforcing foundations. For example, the main advantage of video lectures is that students can easily access them from anywhere using any electronic device (smartphones, tablets, laptops, and computers). All you need is an active and stable Internet connection to play, store, and archive video lectures. This format allows students to learn at their own pace and deepen their understanding, maximizing results. Additionally, students can rewatch the video lecture as needed until they fully understand the concept. Unlike traditional teaching methods, video lectures provide a variety of material presentation styles. Currently, due to the phenomenon of "clip thinking", students often get bored in regular classes, and adding music, illustrations, or experiments to lectures can serve as good motivation and interest for higher education applicants.

As shown above, one of the interesting and promising teaching methods in disciplines such as medicinal, bioorganic, physical, and colloidal chemistry is the use of different types of video tools for distance learning students. Chemistry without laboratory classes is "weak" and incomplete. Misunderstanding the typical laws of chemistry leads to significant problems in material assimilation and further professional development. Therefore, due to martial law in

the 2023–2024 academic year, as well as the lack of many ready-made works in the virtual laboratories listed above, visual video laboratory work was introduced for students of the medical, dental, and pharmaceutical faculties.

In our opinion, it is important to find a balance between traditional and the latest distance learning methods. A good example is the clever combination of video lectures with interesting and useful experiments and elements of virtual laboratories. This option is laboratory work in video format, which allows students not only to study the theoretical aspects of chemistry but also to see the process of conducting experiments, which significantly improves their understanding and memorization of the material.

For example, some works, typically of an analytical nature, such as "Chemical Properties of Carbohydrates", can be independently found on the Internet and viewed in either English or Ukrainian. However, the following issues arise: not all students are willing to invest time searching for the necessary information; the information found may be in an unfamiliar language (English or another language) that the student does not comprehend; different researchers may conduct the same experiment using different methods; the complete list of experiments may be unavailable, or only partial information may be provided (in our study, there are 10 chemical experiments, but the student found an incomplete list); the equipment used may differ from that available at the university, and so on. Due to the numerous problems, primarily related to time consumption, students quickly lose interest in studying chemical disciplines. Therefore, we have developed a collection of video laboratory works following the prescribed curricula and current methodologies. Those works have been uploaded to the Microsoft Teams platform and can be viewed either separately or as part of the recorded lesson.

Let us consider an example of another laboratory experiment conducted for pharmacy students – "Determination of the heat of formation of a crystalline hydrate". Naturally, it is difficult for students to imagine conducting experiments with a calorimeter in a distance learning environment. Usually, they do not even know what this device looks like, why it is needed, or how to work with it. Even a diagram in a handbook or a methodological manual will not help students understand the principle of its operation. Video laboratory work comes to the rescue. The availability of video lectures and online video experiments makes it quite possible to master the educational material under such challenging conditions. Although students cannot work with their own hands, they can still observe, analyze, and at least imagine what a particular device looks like, how to turn it on, and what manipulations need to be performed with it.

The proverb "A picture is worth a thousand words" holds particular significance in education, especially in the sciences, where visualization enhances understanding. One of the most engaging ways to explore scientific concepts is through independent learning. Students can be encouraged to familiarize themselves with traditional literature on a given topic, as understanding theoretical foundations is essential for conducting practical work. Additionally, they can be invited to create their own video content. This process requires them to find relevant video materials demonstrating necessary experiments, verify their accuracy, and ensure alignment with the topic. However, only 10 out of 240 students took on this challenging yet rewarding task, including the co-author of this article, Polina Kolomiiets, a first-year medical faculty student.

Today, numerous platforms facilitate video creation, offering free, partially paid, and premium options. The author, P. Kolomiiets, recommends the following user-friendly tools:

– VEED.IO (https://www.veed.io/login): This platform allows users to merge video segments, translate voiceovers, and generate subtitles automatically. While the free version offers only 15 minutes of usage, it is sufficient, as most edited laboratory videos do not exceed 10 minutes.

– Kapwing (https://www.kapwing.com/): This service enables precise subtitle transfer and formatting, which is particularly useful for chemical formulas.

Jevaga G.V. [14; 15] provides a detailed methodology for creating video content for web-based distance learning. Video materials are valuable for their flexibility and engagement, enabling students to access content conveniently through playlists and revisit sections as needed. Unlike traditional in-person lectures, which have time constraints and limited student capacity, video lectures can be dynamically edited with multiple perspectives. Additionally, well-structured video sequences sustain student attention, while static and animated elements (graphs, histograms, illustrations, and 3D graphics) emphasize key concepts. Thus, educational videos are not merely recordings but well-designed instructional tools that enhance comprehension and maintain interest. The quality of such videos depends more on the instructor's creativity than on technical specifications. Furthermore, an educator's ability to effectively integrate modern multimedia technologies is crucial.

The creation and independent use of such materials can be classified as a heuristic learning method. Searching for relevant materials for practical work requires students to review multiple experiments, which strengthens their knowledge and online research skills. However, this process is time-consuming – a significant challenge given the demanding curriculum of medical students in their first and second years.

Given the current global situation, many students perceive distance learning as a beneficial educational model and, for some, the only viable option. It allows them to study remotely from safe locations while pursuing their academic goals. Additionally, the time saved from commuting can be redirected toward self-study, relaxation – often neglected due to academic pressure – or quality time with family and friends, which is especially important under martial law.

Results of Practical and Pedagogical Research

To improve the learning experience, we integrated various video formats into the curriculum during the 2023–2024 academic year. Natural sciences, particularly chemistry, are among the most challenging subjects to study, especially in a remote format.

To support students' comprehension and preparation for practical and seminar sessions, we provided not only traditional video lectures and practical sessions but also supplementary videos. These included additional explanations, experimental demonstrations, and clarifications of complex concepts, enhancing overall understanding.

Additionally, laboratory work was digitized into video format, enabling students to familiarize themselves with laboratory procedures and techniques visually. This approach deepened their understanding of theoretical and practical aspects of chemical and biochemical processes. By watching laboratory experiment videos, students could analyze each stage, observe real chemical reactions, and develop a clearer grasp of the subject. This method also allowed them to conduct calculations, analyze results, and formulate conclusions, significantly improving their analytical skills. Furthermore, the video format gave students the flexibility to revisit material, reinforcing their practical knowledge. This was particularly beneficial for those who needed additional time to understand certain concepts.

Student Feedback and Survey Analysis

Modern pedagogy emphasizes student feedback, as it helps tailor the educational process to their needs. To assess the impact of video content on learning outcomes and student satisfaction, we conducted a survey among participants in the educational process.

The survey evaluated the effectiveness of diverse video content in studying chemical disciplines by identifying student preferences and satisfaction levels. The 20-question survey included two sections: the first focused on video content, while the second explored students' overall academic experiences and suggestions. Five first-year academic groups participated in the survey.

Students were divided into three groups:

– Group A (active participants in chemistry classes)

– Group B (passive participants)

– Group C (students who had access to laboratory videos but used traditional preparation methods)

Key Findings

Interest in Supplementary Videos: Almost all students engaged with preparatory videos, either watching them in full or focusing on areas where they had knowledge gaps.

– Group Engagement: 81 % of students in Group A watched the supplementary videos, compared to 71 % in Group B. Among Group C, which did not receive additional video resources, 67 % expressed a desire for such materials.

– Effectiveness of Video Materials: 94% of students agreed that the video content helped them prepare for classes. Most preferred to review the material before practical sessions to enhance their grades and understanding.

Given that chemistry is a highly visual science, observing experiments significantly aids comprehension.

– Preferred Platforms: When asked where educational videos should be posted–TikTok, Instagram, Facebook, YouTube, or Microsoft Teams–students overwhelmingly preferred YouTube and Microsoft Teams. The former allows for organized playlists and saved content, while the latter ensures all academic materials are centrally stored.

– Viewing Trends: Despite the availability of recorded lectures, only 25–55 % of students watched them in full, often due to their length (90 minutes). However, 95–100% of respondents acknowledged that video materials were beneficial for class preparation, highlighting a gap in supplementary resources.

Interestingly, one-third of students actively sought additional online content for their studies. However, in the weaker Group C, 10 % did not engage in independent searches, compared to 3.5 % in the average group and 0 % in the strongest group. This indicates a direct correlation between student motivation and engagement.

– Laboratory Demonstrations: 88 % of students considered laboratory demonstrations essential for comprehension and retention.

– Resource Utilization: Nearly all students relied on methodological manuals developed by university faculty as their primary resource, with video materials serving as supplementary tools. Video lectures, recordings of practical classes, and independent searches for online educational videos were utilized in roughly equal proportions.

– Use of AI in Chemistry Learning: When asked whether they used ChatGPT to assist in medical and bioorganic chemistry, students expressed skepticism about its reliability. However, 20 % of students in Group C were more likely to use AI tools, possibly due to gaps in foundational knowledge.

– Overall Satisfaction: Students rated the quality of teaching in medicinal and bioorganic chemistry at approximately 9.3 out of 10, reflecting high satisfaction with faculty instruction at ONMedU.

When asked for additional resources they would like, students suggested more videos of laboratory experiments, explanations of chemical applications in medicine, and opportunities for hands-on practice.

Challenges of Distance Learning

Despite its benefits, many students expressed concerns about the limitations of online education, particularly the lack of in-person interaction and practical skill development. Sample feedback included:

– "The absence of live communication with instructors and peers is a drawback."

– "The subject is fascinating, but hands-on experience would be more beneficial than video demonstrations."

– "While the teaching materials are excellent, I prefer in-person learning."

However, 25 % of students from Groups A and B and 44 % from Group C expressed a preference for continuing distance learning, largely due to safety concerns and personal circumstances.

Recommendations

To enhance the educational experience:

1. Combine traditional methods with modern video formats to improve interactivity and individualized learning.

2. Emphasize digital literacy and etiquette to ensure effective online communication and collaboration.

3. Continue developing high-quality supplementary video materials to support student learning.

Conclusions. It has been demonstrated, that the introduction of diverse video content significantly enhances medical university students' learning quality. Video-based lessons motivate students and improve their academic performance, facilitating adaptation to the distance learning format. Students highly value the role of video materials in preparing for practical classes, highlighting the importance of this approach in the educational process.

It has been observed that digitized laboratory work in video format allows students to gain a detailed understanding of experiments, thereby improving their analytical skills and fostering a deeper understanding of the practical aspects of chemistry.

The study revealed varying levels of student engagement with supplementary videos. More active groups accessed video materials more frequently, while less active groups also expressed interest in additional resources. Students prefer YouTube and Microsoft Teams as convenient platforms for viewing and storing educational content.

Students with higher motivation actively engage with additional resources, whereas less interested groups are less likely to independently seek out materials. Despite the advantages of video content, students highlight the limitations of distance learning, particularly the lack of live interaction and practical skill development.

The use of video materials eases teachers' preparation for practical classes in the context of distance learning. Furthermore, laboratory experiments in video format are more cost-effective and multifunctional, as they allow students to observe practical experiments while simultaneously recording the necessary information for calculations.

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