

Incorporating Information Technology into the Teaching of the “Analytical Chemistry” Course at Bogomolets National Medical University

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Abstract

In the past ten years, the popularity of electronic learning has increased significantly, with technology-enhanced education becoming a key area of study and research. The information age offers unmatched opportunities for educational advancement, including enhanced communication, access to up-to-date information, and knowledge exchange. The need for e-learning is anticipated to continue growing. The integration of digital technologies and resources opens avenues to improve the effectiveness of both learning and teaching. This article discusses the experience of organizing an e-learning course on “analytical chemistry” at Bogomolets National Medical University for 488 second-year pharmaceutical students (93 full-time and 395 part-time students). The course used Moodle and various other digital tools such as pre-recorded video lectures, Zoom, laboratory work, and social media platforms. The objective of this article is to assess and analyze the use of information technology in education, especially during the COVID-19 pandemic. An important outcome of this study is the development of a well-organized online analytical chemistry course on the LIKAR_NMU platform. Student performance evaluation shows that the proposed online learning approach effectively supported the acquisition of essential knowledge and skills in analytical chemistry. The survey results show that live sessions and pre-recorded video lectures were equally effective in several criteria, including focus, clarity, engagement, and overall quality. In addition, social networks such as Viber, WhatsApp, and Telegram are effective tools for addressing supplementary issues related to the analytical chemistry course.

Keywords: Analytical chemistry, Distance learning, Education, Electronic learning, Information technology

Introduction

In recent years, technology has not only been advancing at a fast pace but is also transforming various aspects of society, including education, communication, and professional life [1]. The widespread integration of social media networks and information technologies in education has become evident, as modern teenagers are highly adaptable to technology and have constant access to diverse communication platforms such as social media and mobile phones [2].

Education is among the sectors most affected by technological advancements. Consequently, the significance of e-learning has grown substantially over the past decade, making it an increasingly vital component of the educational landscape [3-6].

The idea of online education is not a recent development. As described in the online Encyclopedia Britannica, “distance learning” involves an educational format where the primary components are the physical separation of instructors and students, along with the use of different technologies to support communication between students and instructors, as well as between students themselves.

A key concern surrounding online learning is how its effectiveness compares to traditional face-to-face education. E-learning offers both benefits and drawbacks in comparison to conventional methods. One of its key advantages is the flexibility it provides, allowing

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individuals to learn or train at their own pace, whenever they have free time, and from any location. However, one significant limitation of e-learning is the absence of in-person interaction that traditional learning offers [7, 8].

E-learning has become increasingly prevalent across various sectors. It is applied in fields such as industrial engineering education, medicine, higher education, and administrative sciences [9-14]. Systematic reviews [3, 15-18] provide valuable insights into the development of distance learning.

Chemistry plays a crucial role in many scientific disciplines, including medicine, biology, pharmacy, physics, engineering, and materials science. However, there are limited studies that specifically examine online learning in undergraduate chemistry courses, such as those in inorganic chemistry [19], general chemistry [20], and introductory chemistry [21]. This paper aims to address this gap.

The focus of this study is to evaluate the effectiveness of the educational process at Bogomolets National Medical University during the pandemic, using Learning Management Systems like Moodle, along with other technological tools (Zoom, pre-recorded lectures, laboratory exercises, and social networks). The paper examines both student performance and attitudes, which are critical factors in assessing the success of online courses. It considers student learning outcomes, including test results and overall grades, as well as students' perceptions of the proposed online chemistry course.

Materials and Methods

In response to the COVID-19 pandemic, Bogomolets National Medical University transitioned to online and blended learning models during the 2020/2021 academic year. To support distance education during the quarantine period, the university implemented the LIKAR_NMU platform, which is based on the Moodle learning management system [22]. Moodle serves as a valuable resource hub and holds significant potential for enhancing educational experiences. It is widely used in higher education to enhance both teaching and learning [23, 24].

The LIKAR_NMU platform, along with detailed instructions for both educators and students on its usage, can be found on the website of the university.

At Bogomolets National Medical University, second-year pharmaceutical students, both part-time and full-time, are required to take an Analytical Chemistry course during their 3rd and 4th semesters. The course accommodates 488 students in total, with 93 full-time and 395 part-time students. For full-time students, the course includes fifteen lectures (thirty hours) and thirty practical sessions (120 hours), while part-time students attend four lectures (seven hours) and eighteen practical sessions (36 hours), amounting to a total of eight credits. The curriculum is divided into three modules: “qualitative analysis” (10 topics), “quantitative analysis” (14 topics), and “instrumental methods of analysis” (six topics).

Analytical chemistry is also a part of the unified state qualification exam for students enrolled in the Master's program within the “22 Healthcare” field of study (<https://www.testcentr.org.ua/en/usqe>), which highlights its importance [25, 26].

The use of the LIKAR_NMU distance learning platform facilitates effective interaction between instructors and students, allowing for a structured and organized learning experience [27]. **Figure 1** illustrates how the Analytical Chemistry courses are structured on the LIKAR_NMU platform at the university.

Let's take a closer look at the course modules.

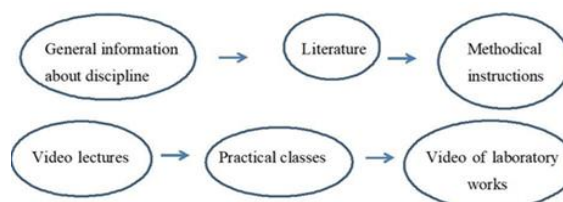


Figure 1. The key components of the “Analytical Chemistry” course structure on the LIKAR_NMU distance learning platform

The “General Information about the Discipline” module provides PDF files containing the educational curriculum, a calendar-based plan for practical sessions, and a schedule for lectures. This material is crucial for students as it supports their efforts to meet the objectives outlined in the “Analytical Chemistry” course.

The “Literature” module offers PDF files of the primary textbooks, along with a list of supplementary materials that include comprehensive reference details.

The “Methodological Instructions” module contains PDF files with detailed guidance for each practical session (a total of 30 instructions). These instructions are designed to assist students in independently mastering the theoretical concepts of “Analytical Chemistry.” Each practical lesson includes an overview of the topic’s relevance, the general and specific objectives, essential skills, key questions, vocabulary, and a list of references with specific pages to study. Additionally, each session includes problem sets for homework, along with solutions for guidance.

The “Video Lectures” module features nine pre-recorded video lectures for full-time students (along with 6 live Zoom sessions) and 19 pre-recorded lectures for part-time students. Lecturers utilize PowerPoint with voiceover to create these online lectures. This method allows instructors to provide spoken explanations for examples, tables, facts, and graphs. The final version of these lectures is saved as mp4 video files. The part-time education model is tailored for students who need to balance work or family responsibilities, and it is delivered in a more concise format. As a result, short video lectures were produced for each practical session, including an additional video on laboratory safety rules, to enhance the quality of distance learning.

The “Practical Classes” module offers tasks for continuous assessment during each practical session, along with a student notebook for experimental chemistry. The assessment includes multiple-choice questions, calculations, and situational problems.

The “Laboratory Work Videos” module contains videos demonstrating all experiments outlined in the educational curriculum, totaling 26 laboratory work videos.

Results and Discussion

Qualitative research was conducted through student interviews to assess the advantages and disadvantages of the proposed online learning approach. A total of 71.1% of students rated the course as effective in acquiring the necessary knowledge and skills, noting its well-organized structure.

However, our observations, along with feedback from 63.1% of students, highlighted some drawbacks of online learning. The primary concern is the absence of hands-on laboratory experiments, which are crucial in chemistry as an experimental science. As a result, students lack

practical experience in using laboratory equipment correctly and safely.

The objective of this study was to evaluate and compare the effectiveness of live Zoom sessions and pre-recorded video lectures. Respondents were asked to rate how effective each format was in helping them grasp the concepts in the “Analytical Chemistry” course. Among full-time students, 45.2% favored pre-recorded video lectures, 47.3% preferred live Zoom sessions, and 7.5% expressed a neutral opinion. A different trend emerged among part-time students, with 80.1% opting for pre-recorded video lectures, while only 8.7% favored live Zoom sessions, and the remainder did not offer an opinion. These preferences can be attributed to the different learning conditions of the two student groups. Part-time students typically experience greater autonomy in their learning due to their flexible schedules, making pre-recorded video lectures a more practical and valuable resource for acquiring and enhancing their knowledge. With the ability to access the lectures anytime and anywhere, students find this format especially convenient. Furthermore, both types of lectures were evaluated on a 5-point scale (five = “very good”, 1 = “very poor”) based on criteria such as concentration, clarity, level of interest, and overall quality. The average scores revealed that both pre-recorded and live Zoom lectures were equally effective. Notably, video lectures offer several advantages, including the ability for students to watch them at their convenience, allowing for repetition and deeper understanding, which is particularly beneficial when preparing for exams.

Average percentage values for the criteria of pre-recorded video lectures and live Zoom sessions are presented in **Table 1**.

Table 1. Average percentage values for the criteria of pre-recorded video lectures and live Zoom sessions

Criterion	Live Zoom sessions	Pre-recorded video lecture
Focus and attention	3.0	3.4
Clarity of content	3.3	3.1
Level of engagement	3.3	3.4
Overall lecture experience	3.1	3.2

Each practical session, as per the schedule, is conducted as a videoconference via Zoom, enabling real-time

interaction. Zoom was selected for its key features, such as:

- Recording capability, which is beneficial for students with limited internet access.
- Easy screen sharing, offering instructors the flexibility to utilize tools like PowerPoint, whiteboard functions, etc., essential for teaching chemical sciences (e.g., displaying videos, writing chemical equations, and discussing problem solutions).

Social media platforms are also integrated into the educational experience as an extra component of the “analytical chemistry” course. Among various communication tools, messengers like Viber, Telegram, and WhatsApp were recommended for students to choose for educational purposes. The breakdown of social media usage by platform is shown in **Table 2**. Telegram emerged as the most widely used among our students. Additionally, 41 separate messenger groups were created for second-year pharmaceutical students, based on their preferences.

Table 2. Percentage and number of social network users by differentiating the software

Type of social network	The number of social network users
Viber	151 (30.9%)
Telegram	199 (40.8%)
WhatsApp	138 (28.3%)

The social media application serves several purposes within the educational framework, including:

- Promoting information sharing among students,
- Boosting student motivation toward the course,
- Disseminating audio recordings, problem-solving materials, and subject-related documents,
- Providing instant clarification for unclear topics,
- Serving as reminders for assignment deadlines.

A survey was conducted to assess students' perceptions of the effectiveness of social networks in addressing their learning needs. The responses were categorized as follows: highly effective (29%), moderately effective (38%), and minimally effective (33%).

Participation in the surveys was voluntary. The findings on the role of information technology in the delivery of the “analytical chemistry” course at Bogomolets National Medical University align with student engagement on the

distance learning platform LIKAR_NMU: 56% of students achieved scores between 80% and 100%, 30% performed between 70% and 80%, and 14% scored below 70% (**Figure 2**). It is noteworthy that full-time students generally had higher performance levels compared to part-time students, which can be attributed to factors such as reduced study time and less direct oversight from instructors.

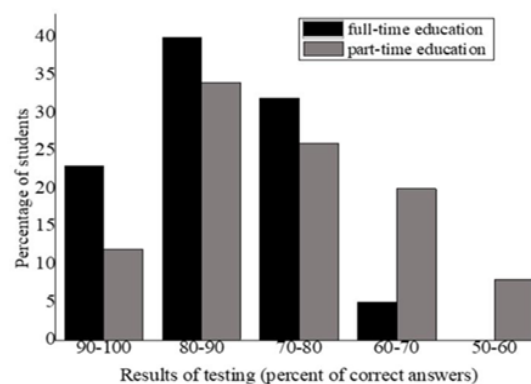


Figure 2. The results of testing of students on the distance learning platform LIKAR_NMU

The outcomes of the “qualitative analysis,” “quantitative analysis,” and “instrumental methods of analysis” submodule assessments for full-time students are presented in ECTS grades, as shown in **Table 3**. The majority of students received grades A, B, and C.

Table 3. Distribution of students based on the grades A, B, C, D, or E in the online course

Submodule	A (%)	B (%)	C (%)	D and E (%)
Qualitative analysis	28 (30.1%)	35 (37.6%)	25 (26.9%)	5 (5.4%)
Quantitative analysis	31 (33.3%)	34 (36.6%)	20 (21.5%)	8 (8.6%)
Instrumental methods of analysis	22 (23.6%)	30 (32.3%)	31 (33.3%)	10 (10.8%)

We observed a decline in students' performance from the “Qualitative analysis” submodule to the “Instrumental methods of analysis” submodule. To gain insight into this trend, we asked students to share their perspectives. Here are some representative comments reflecting their experiences with the course:

“I organized the online course “analytical chemistry” based on increasing complexity: first “qualitative analysis,” followed by “quantitative analysis,” and finally “instrumental methods of analysis.”

“I achieved a grade of B in both the ‘Qualitative analysis’ and ‘Quantitative analysis’ submodules, but only a D in ‘Instrumental methods of analysis.’ I found the ‘Instrumental methods of analysis’ section particularly challenging as it demands practical skills and a deep understanding of various chemical and physical concepts like electrochemistry and optics.”

Conclusion

The results lead to several conclusions. The distance learning platform LIKAR_NMU, built on the LMS Moodle, along with features such as video conferencing, social software, and pre-recorded video lectures, proves to be a highly effective tool for online education. The LIKAR_NMU platform is suitable for providing students with the necessary training and skills for their future professions. Key advantages of this platform include its intuitive interface, efficient content management, responsive design, flexible testing and assessment options, and tracking capabilities to monitor student progress throughout the learning process.

Survey results highlight the effectiveness of pre-recorded lectures in acquiring the essential knowledge and skills for “analytical chemistry,” as well as the successful use of social media platforms like Telegram, Viber, and WhatsApp for teacher-student communication outside the classroom. The integration of video lectures has the potential to enhance teaching quality, especially given the improved student concentration and engagement levels observed with pre-recorded videos compared to live Zoom lectures. Social media platforms serve as valuable tools in supporting educational goals, such as information sharing among students and boosting motivation. Among these platforms, Telegram was the most widely used, followed by Viber and WhatsApp.

Our findings show that the majority of full-time students achieved grades of A, B, and C in the submodules “qualitative analysis,” “quantitative analysis,” and “instrumental methods of analysis” in the online course format. The high performance of these students in the “analytical chemistry” course further supports the conclusion that online learning can be as effective as traditional in-person instruction.

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