

Effect of distance, mixed and face-to-face learning on pharmacy students' performance in Biochemistry in Ukraine

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ABSTRACT

The study of the academic progress in Biological Chemistry in the students of the Faculty of Pharmacy during distance, mixed, and face-to-face learning was conducted to determine the students' levels of perception of distance learning technologies. The results of the qualification exam (n=225) in 2018-2021 were compared in terms of absolute academic progress, quality of knowledge, training levels, and grades using one-way ANOVA. 95% of the students took part in a voluntary survey in the form of an anonymous questionnaire. There is a statistically significant difference in the academic progress of the students in mixed and distance learning programs. Despite the influence of the form of learning on the student's academic progress, the proportion of the effect of the form of learning on the progress is small and amounts to about 5%. 56.4% of the surveyed students mentioned a lack of live communication with the teacher, limited "teacher-student" contacts during online classes, and permanent limitations of feedback, which created psychological discomfort in the process of distance teaching. The study emphasized the importance of cognitive function development in the students during distance learning. Further monitoring of the student's academic progress will help to optimize distance learning in pharmaceutical education.

Keywords: Distance learning, Academic performance, One-way ANOVA, Pharmacy biochemistry

Introduction

The rapid spread of the SARS-CoV-2 virus worldwide has caused significant changes in all spheres of society in Ukraine [1, 2]. First of all, the strategy for the development of education has been revised [3, 4]. Until now, the possibility of full distance learning has not been considered due to the peculiarities of professional training of future specialists in the field of knowledge 22 "Health Care." As an anti-pandemic measure, the introduction of distance teaching in higher medical (pharmaceutical) education is a global trend. Online classes at the Faculty of Pharmacy of the Bogomolets National Medical University (NMU) of the Ministry

of Health (MOH) of Ukraine in the second half of academic year 2019-2020, continuation in academic year 2020-2021 and an unpredictable period of quarantine determine the relevance of monitoring of the quality of knowledge in the students of higher education institutions with various forms of educational process (face-to-face, distance and mixed) in the institutions of higher medical (pharmaceutical) education.

On the one hand, distance education requires quick adaptation to higher education under modern conditions, develops students' skills of independent work with educational materials, enhances their mobility, and motivates self-education, which contributes to the development of professional competencies [5-9]. On the other hand, the main disadvantage of distance learning is the possibility of incorrect assessment of the student's knowledge by the teacher due to the inability to accurately verification whether the student used additional materials during the study, including those found on the Internet, or whether the student responded to the proposed questions himself. In other words, control of knowledge, skills, and abilities of the students during distance learning should assess the training levels of the students as

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objectively as possible in accordance with the requirements of educational and qualification characteristics [10].

Biological chemistry is one of the basic disciplines in the medical and pharmaceutical education system. The purpose of mastering its content is the formation of special (professional, subject) competencies, i.e., the ability to explain biochemical and molecular mechanisms of pathological processes in humans and principles and mechanisms of pharmacotherapy; to interpret the results of biochemical laboratory tests to assess the physiological condition and efficacy of pharmacotherapy; to use reference and medical literature. As biological chemistry lays the foundations for the students to study professional disciplines – pharmacology, clinical pharmacy, pharmacotherapy, drug toxicology, toxicological and forensic chemistry, etc., an insufficient level of its mastering can significantly affect the formation of professional competencies.

According to the working curriculum for the training of specialists of the second (master's) level of higher education in the field of knowledge 22 "Health Care" specialty 226, "Pharmacy, Industrial Pharmacy," approved by the Academic Council of the Bogomolets NMU, the discipline of Biological Chemistry is studied in semester IV of the 2nd year and in semester V of the 3rd year, total 180 hours (70 hours of practical classes, 30 hours of lectures and 80 hours of independent work) [11]. The program of the discipline "Biological Chemistry" provides for the initial, current, intermediate, and final control of students' knowledge, skills, and abilities throughout the entire period of teaching the discipline "Biological Chemistry." The list of types and methods of control, means of diagnosing students' knowledge, criteria for assessing individual forms of knowledge control, the scheme of calculation, and distribution of points received by students for the discipline are presented in the relevant sections of the curriculum of the discipline "Biological Chemistry."

In 2019, Ukraine introduced an independent Unified State Qualification Exam (USQE) for the applicants for a Master's Degree in the field of knowledge 22 "Health Care." USQE is taken after the 3rd year of study (USQE stage 1) and after mastering the disciplines of the 5th year of study (USQE stage 2). The exam is organized and conducted by the Center for Testing the professional competence of specialists with higher education in Medicine and Pharmacy at the MOH of Ukraine. The obligatory component of the first stage of the USQE is the integrated test exam "KROK1. Pharmacy", which is taken after studying basic fundamental disciplines, including analytical chemistry, physical and colloid chemistry, organic chemistry, biological chemistry, pathological physiology, microbiology, pharmaceutical botany, and pharmacology. Students who fail to overcome the cutoff score of the USQE do not receive a diploma of higher medical (pharmaceutical) education. Centralized testing at the state level deserves special attention, as the results of centralized testing make it possible to monitor the level of training of graduates of higher medical (pharmaceutical) education institutions, to conduct an examination of the quality

of education using independent pedagogical analysis and to make decisions on improving the educational process.

According to the preceding explanations, the purpose of this study was to examine what changes in the organization of the educational process (distance, mixed, face-to-face learning) affect students' achievements during their academic activities in higher medical (pharmaceutical) education. For this purpose, the results of the assessment of knowledge, skills, and abilities in the discipline "Biological Chemistry" of students of the Faculty of Pharmacy were analyzed both within one educational institution and at the state level.

Materials and Methods

Participants

The analysis of the academic achievements of students in Biological Chemistry was conducted at the Department of Medicinal Chemistry and Toxicology of the Faculty of Pharmacy of the Bogomolets NMU of the MOH of Ukraine. The study investigated the results of the academic achievements of 225 students (168 females and 57 males aged 19 to 21 years) in the 3rd year based on academic progress, grades in the discipline of Biological Chemistry and the results of the subtest as part of the integrated test exam "KROK 1. Pharmacy" during face-to-face (2018-2019 academic year, group 1), mixed (face-to-face/distance) (2019-2020 academic year, group 2) and distance (2020-2021 academic year, group 3) teaching.

Data collection and analysis

To assess the knowledge, skills, and abilities of the students upon completion of the course, the final control in the form of a standardized exam, according to the directive approved by the Cyclic Methodical Commission on the specialty "Pharmacy, industrial pharmacy," which included control of theoretical and practical training, was carried out. The exam consisted of three blocks: computer-based testing on the LIKAR_NMU (Technomatix) [12] distance learning platform, testing in written form, and a written answer to the open-ended task. To assess theoretical knowledge, preference was given to standardized test control using a variety of tests: form A tests (with one correct answer), tests with multiple choice for recognition, compliance, sequence of actions, classification tests, etc. Grades in Biological Chemistry were given as the sum of points for the current activity and the exam and were determined by the European Credit Transfer System (ECTS) on a four-point scale: "excellent," "good," "satisfactory," and "unsatisfactory," adopted in Ukraine [13].

95% of the students (134 females and 31 males aged 19 to 21 years) who had experience in distance learning took part in a voluntary survey in the form of an anonymous questionnaire, answering three following questions: 1) How do you feel about teaching Biological Chemistry in the form of distance teaching? Why? 2) What exactly made you feel this way? Why? 3) How did

distance teaching of Biological Chemistry affect you in terms of your learning experience?

The levels of knowledge, skills, and abilities acquired by the students were evaluated using the methods commonly used in the higher education institutions of Ukraine, including determination of absolute academic progress, quality of knowledge, mean grade, and training levels (according to V.P. Simonov) [14, 15].

The calculation of absolute academic progress (overall progress rate) (% of students who have positive grades "5", "4" and "3") was carried out according to the Eq. 1:

$$\text{Absolute academic progress} = \frac{N - N_2}{N} \times 100\% \quad (1)$$

where N - number of students who received grades; N₂ - number of students who received unsatisfactory grades "2".

Progress level scale: high level (100% - 90%); acceptable level (89% - 75%); satisfactory level (74% - 50%); alarm level (49% - 40%); critical level (39% - 0%).

The calculation of the quality of knowledge (qualitative parameter of progress) (% of students who have high and sufficient levels of knowledge (grades "5" and "4")) was carried out according to the Eq. 2:

$$\text{Quality of knowledge} = \frac{N_4 + N_5}{N} \times 100\% \quad (2)$$

where N - number of students who received grades; N₄ - number of students who received a grade "4" good; N₅ - number of students who received a grade "5" excellent.

The scale of the qualitative parameter of progress: high level (100% - 50%); acceptable level (49% - 30%); satisfactory level (29% - 25%); alarm level (24% - 15%); critical level (14% - 0%).

The training levels of the students (TLS) (the sum of their ideas, knowledge, skills, abilities, and competencies) were calculated by the Eq. 3:

$$\text{TLS} = \frac{Ax + By + Cz + Dh}{N} \times 100\% \quad (3)$$

where N - number of students who received grades; A, B, C, D - constant coefficients: A = 1, B = 0.64, C = 0.36, D = 0.16; x - number of students who received grade "5" excellent; y - number of students who received grade "4" good; z - number of students who received grade "3" satisfactory; h - number of students who received grade "2" unsatisfactory

The scale of the training levels: high level (100% - 64%); sufficient level (63% - 36%); average level (35% - 14%); low level (13% - 0%).

The analysis of the student's grades in Biological Chemistry and the results of the subtest as part of the integrated test exam "KROK 1. Pharmacy" was carried out using two statistical methods: descriptive statistics and one-way ANOVA (analysis of variance). The differences between the studied groups were verified using the Scheffe test (post hoc test) after a one-way ANOVA Scheffe test for multiple comparisons [16, 17].

Results with a p-value lower than .05 were considered statistically significant. Statistical data analysis was performed using Prism 9.5.1 (GraphPad Software Inc., USA) and MS Excel (Statistical Functions and Analysis Package).

Results and Discussion

Due to the pandemic, the transition in the second half of the 2019-2020 academic year to distance learning was a serious challenge for all participants in the educational process (students, teachers, and management of higher medical (pharmaceutical) education). Despite the presence of the LIKAR_NMU educational platform for distance learning at the Bogomolets NMU since 2017, qualitative parameters of students' progress in biological chemistry, presented in **Table 1**, were the lowest in Group 2 compared to Group 1 and Group 3. In group 2 compared to group 3, there was a decrease of 10.11 % in absolute academic progress and 7.62 % in qualitative progress due to an increase in the number of "unsatisfactory" grades.

Table 1. Students' Academic Achievements in Biological Chemistry

Academic progress		Face-to-face learning, % (n=51)	Mixed learning, % (n=78)	Distance learning, % (n=96)
Final exam	Absolute academic progress	92.0	82.0	94.0
	Quality of knowledge	30.0	22.0	36.0
	Students' training levels	43.0	39.0	48.0
	Number of grades "5" Excellent	0.0	0.0	9.4
	Number of grades "4" good	29.4	21.8	26.0
	Number of grades "3" satisfactory	62.8	60.3	58.3
	Number of grades "2" unsatisfactory	7.8	17.9	6.3
Number of students who did not pass the subtest in Biological Chemistry in USQE		10.4	9.4	33.3

A comprehensive certification of specialized knowledge of students-pharmacists is a licensing test exam in the main, fundamental disciplines "KROK 1. Pharmacy", which, in

particular, includes 10-14% of tests in Biological Chemistry. The data presented in **Table 1** show that in academic years 2018-2019 and 2019-2020, 10.4% and 9.4% of students did not pass

the exam in biological chemistry, respectively. However, in the academic year 2020-2021, 33.3% of 3rd-year students of the Faculty of Pharmacy of the Bogomolets NMU could not achieve the minimum passing score (60%) for "KROK 1. Pharmacy". At the same time, given the academic results of these students, the content of the tests should not have caused problems for most students.

In order to achieve the objective of the study, the student's grades in Biological Chemistry and the results of the subtest as part of the integrated test exam "KROK 1. Pharmacy" were analyzed in three groups using descriptive statistics. Major parameters of descriptive statistics are presented in **Table 2**.

Table 2. Descriptive statistics of students' academic achievements in Biological Chemistry

Academic progress	Group	Average	Standard deviation, SD	Standard error, SE
Final exam	Group 1	3.216	0.5767	0.08075
	Group 2	3.038	0.6333	0.07171
	Group 3	3.385	0.7451	0.07605
Subtest of the USQE	Group 1	4.229	0.9728	0.1404
	Group 2	4.156	0.9795	0.1224
	Group 3	3.411	1.198	0.1263

Table 2 shows that the mean grade in each of the three groups is different, but in order to find out whether these differences are statistically significant, we formulated the null hypothesis H₀ (that the form of learning does not affect the academic progress

of the students in Biological Chemistry) and the alternative hypothesis H₁ (that the form of learning affects students' grades in Biological Chemistry). A one-way ANOVA was used to test the null hypothesis.

Table 3. Differences between distance, mixed, and face-to-face learning groups by using one-way (ANOVA)

Academic progress	One-way ANOVA					
	Source of variation	Sum of Squares Deviations (SS)	Degrees of freedom (df)	Mean Square (MS)	Fstat	p-value
Final exam	Between Groups	5.188	2	2.594	5.745	.0037
	Within Groups	100.3	222	0.4516	-	-
	Total	105.4	224	-	-	-
Subtest of the USQE	Between Groups	30.23	2	15.11	12.92	<.0001
	Within Groups	232.7	199	1.166	-	-
	Total	262.9	201	-	-	-

The results of the one-way ANOVA presented in **Table 3** show that the calculated value of the F test is greater than the critical value. Thus, the null hypothesis H₀ is rejected in favor of the alternative hypothesis H₁. This means that the form of education has an impact on the progress of the students in Biological Chemistry. It should be noted that by rejecting the H₀ hypothesis, we get no answer to the following question: "To what extent does the form of learning affect students' progress?" Such a question can be answered by calculating the ANOVA effect size R² [18] which in our study was equal to 0.05 for the final exam and 0.12 for the subtest of the USQE for groups 1, 2, and 3. Therefore, our study showed that the degree of the effect of the form of learning on progress rates is small during current learning. However, for an independent exam, the form of learning has a moderate effect. We can assume that other factors, such as students' motivation, teachers' professionalism, students' cognitive abilities, work capacity, practical component of a pharmacist's training, which will ensure the effectiveness of the

process of forming their professional competencies and others, have a greater influence on the student's progress rates. Since the p-value in **Table 3** is less than .05, it means that none of the studied student groups has the same level of knowledge in biological chemistry.

Next, we will perform Scheffe's test to determine which groups are different. According to the data in **Table 4**, the Fstat that exceeds Scheffe's Critical Value is the one for the comparison between group 2 vs. group 3 both for the final exam and for the subtest of the USQE. Thus, the only two groups that are statistically significantly different both for the final exam and for the subtest of the USQE are Group 2 (academic progress in students with mixed learning) and Group 3 (academic progress in students with distance learning). Also, we can see that the only two groups that are not statistically significantly different both for the final exam and for the subtest of the USQE are group 1 (academic progress in students with face-to-face learning) and group 2 (academic progress in students with mixed learning).

Table 4. Multiple comparisons by Scheffe test

Academic progress	X	Y	Mean Difference (X-Y)	Mean square between (MSw)	Fstat	p-value
Final exam	Group 1 vs. Group 2		0.1772	0.4516	2.1441	.0955
	Group 1 vs Group 3		0.1697	0.4516	2.1239	.0980
	Group 2 vs Group 3		0.3470	0.4516	11.4741	.0001
Subtest in USQE	Group 1 vs. Group 2		0.07292	1.136	0.0372	.9904
	Group 1 vs Group 3		0.8181	1.136	14.303	.0001
	Group 2 vs Group 3		0.7451	1.136	18.279	.0001

The first experience of distance learning in the academic year 2019-2020 outlined the main tasks and areas for improvements in the organization of the educational process. First of all, the search for software applications that allow direct contact between the teacher and the student was conducted, which provided, above all, assistance to the students in acquiring basic knowledge, activated and motivated their creative work, found links between theoretical knowledge and practical activities. The Internet platform Zoom (Zoom Video Communications) or Google Meet (Google) was chosen for practical classes in biological chemistry, which allowed the teacher to demonstrate educational materials in the form of presentations and videos, to give the students tests and short written tasks in chat and analyze situational problems/cases.

In order to ensure the quality of the educational program in the conditions of distance and hybrid learning, the Department of Medicinal Chemistry and Drug Toxicology of the Faculty of Pharmacy of the Bogomolets National Medical University has developed various teaching materials, in particular methodological developments for preparation for practical classes in biological chemistry, containing a list of theoretical questions, assignments for students' independent work and self-control of knowledge on the topic of the class, situational tasks and tests to test different levels of learning. To ensure a full and high-quality educational process in the conditions of distance and blended learning, videos were edited to show the methodology of conducting a study of the main biochemical parameters of blood, urine, and saliva. Students recorded the results of their observations in the video in a laboratory log. The latter is aimed at developing the practical skills that students should master upon completion of the discipline. The above-mentioned materials were posted on the distance learning platform LIKAR_NMU. To deepen the level of theoretical knowledge of students in the process of studying the course of biological chemistry and preparation for the Unified State Qualification Examination (USQE) "Krok 1. Pharmacy", the teachers of the department prepared a textbook "Biological Chemistry. Test tasks with explanations for students of the Faculty of Pharmacy". Upon completion of the discipline "Biological Chemistry," Google Forms software was used to objectively and qualitatively control students' knowledge. Google Form provides simultaneous online control using a variety of tasks: multiple-choice recognition tests, matching tests, short-answer surveys, and solving situational tasks that demonstrate a particular biochemical process or reaction, the name of which must be specified.

Despite insufficient levels of digital literacy and digital competence of the participants of the educational process and lack of necessary technical support (laptop, modern computer, Internet access, etc.), changes in the organization of the process of studying biological chemistry contributed to the improvements in students' academic progress. In group 3, compared to group 2, the absolute academic progress increased by 11.71 %, and the qualitative parameter of academic progress increased by 13.62 %. This was due to an increase in the number of excellent grades and a decrease in the number of unsatisfactory grades in Biological Chemistry. In addition, the absolute academic progress of the students during distance learning did not differ significantly from that during face-to-face learning, while the quality increased from 29.42 % to 35.42 % during distance learning. In Group 1 and Group 3, the rate of overall progress was high compared to Group 2 (mixed learning), when it was acceptable. The qualitative parameter of students' progress during face-to-face learning in the academic year 2018-2019 corresponded to a satisfactory level. In the academic year 2019-2020, with a mixed form of education, this parameter characterized an alarm level. During distance learning in the academic year 2020-2021, the quality progress parameter was at an acceptable level. The training level of the students was sufficient for all forms of learning.

Even though during distance teaching of Biological Chemistry, students demonstrated high academic progress based on the results of the internal examination session, compared to face-to-face and mixed forms of teaching, the results of the in-person licensing test "KROK 1. Pharmacy" as part of the USQE in the academic year 2020-2021 indicate a number of problems in the organization of distance education. In our opinion, the main problem is that all students do not adhere to the principle of academic integrity in distance learning. The solution lies in improving the methods and practices of assessing students' academic achievements. They need to be improved, and new forms of control need to be found to prevent cheating, falsification, and fraud.

A sociological survey (questionnaire) was conducted to identify students' attitudes towards the distance form of learning the discipline "Biological Chemistry." According to 56.4% of the students, the lack of live communication with the teacher, limited contact between teachers and students during online classes, and permanent limitations of feedback create psychological discomfort in the process of distance learning. 41.6% of the surveyed students say that they have problems with

planning time for studies because, in preparation for practical classes, they are forced to master a large amount of new material by reading textbooks or watching video lectures, which negatively affects their interest in studying in general. In 18.0% of the students, low learning outcomes are associated with a lack of motivation to study and the ability to study independently, significantly hindering knowledge acquisition. Thus, overcoming the lack of skills of self-organization and self-control, inadequate self-assessment of their knowledge, high levels of anxiety in students during the exam, and unformed value-semantic attitude to the exam will primarily contribute to the successful passing of the Unified State Qualification Exam (USQE) for the applicants for a Master Degree in the field of knowledge 22 "Health Care."

Conclusion

The discipline "Biological Chemistry" is integrally related to practical research, experimentation, and testing of theoretical knowledge and skills in practice. The study shows that despite the influence of the form of study on student performance, the share of the influence of the form of study on performance is small and amounts to about 5%. Despite the influence of the form of learning on the student's academic progress, the proportion of the effect of the form of learning on the progress is small and amounts to about 5%. However, the share of the influence of the form of study on the results of the full-time independent examination (USQE) is about 12%. This difference in figures may be due to the different assessment forms of students' knowledge. What is important is that forced conditions of distance teaching in higher medical (pharmaceutical) education institutions created new experiences and influenced the development of the information and communication culture of teachers and students, highlighting psychological aspects of distance communication between teachers and students. It is worth paying attention to the fact that during distance learning, the information and communication culture of the teacher and the student, the psychological aspects of remote communication between the teacher and the students, the personal qualities of the students, as well as their cognitive and metacognitive abilities are highly important. The students who study using this form of teaching should have a high level of motivation, self-discipline, and self-control. Improvements in online systems for training and assessment of students' knowledge, taking into account their cognitive characteristics, will help to increase the level of professional training and development of competencies necessary for mastering the future profession of a pharmacist. Further monitoring of the student's academic progress in various education forms will help optimize assessment methods and improve the quality of pharmaceutical education.

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