

## Designing an Online Course for Pharmacy Students: Case Study of Basics of Chemical Metrology

**Yaroslava Pushkarova**

Department of Analytical, Physical and Colloid Chemistry, Bogomolets National Medical University, Kiev, Ukraine, [yaroslava.pushkarova@gmail.com](mailto:yaroslava.pushkarova@gmail.com)

**Galina Zaitseva**

Department of Analytical, Physical and Colloid Chemistry, Bogomolets National Medical University, Kiev, Ukraine, [galinazaitseva777@gmail.com](mailto:galinazaitseva777@gmail.com)

This article discusses the design of the online elective course “Basics of chemical metrology” and experience of part-time second year students of study of the pharmaceutical faculty at Bogomolets National Medical University for academic years 2020-2021 and 2021-2022). The attitude of students to the online course was assessed by using quantitative post-course survey. Most of part-time students reported that they would recommend this elective course to other students. Overall, students felt that the course was well-organized with effective delivery of material and useful case studies. The pharmacy case studies presented in this work illustrated that the chemical metrology is the important section of analytical chemistry and gave the part-time pharmacy students an insight into the different roles of the chemical metrology in pharmacy industry. Course “Basics of chemical metrology” is useful and interesting for pharmacy students and can be recommended for learning. Case studies together with distance learning platform LIKAR\_NMU and pre-recorded video lectures are effective online learning tools.

Keywords: analytical chemistry, chemical metrology, distance learning, pharmacy education

### INTRODUCTION

Measurements are an important part of everyday life for thousands of years and nowadays. Measurements drive decision-making in nearly all aspects of modern society and that is why advances in measurement science and standards are so important (Mroczka, 2013; Crowder et al., 2020). Measurement is the process of experimentally obtaining quantity values that can be attributed to a property of a body or substance (Czichos et al., 2011).

The role played by analytical chemistry has become more important due to the growing need for development and validation of new materials, new procedures, devices and instrumental configurations particularly in the biological and biomedical sciences and biotechnology. Analytical chemistry also has a significant presence in the pharmaceutical industry, especially in the ensuring the quality, purity, identity, and strength of each lot of drug product manufactured. There is increased emphasis on analytical chemistry as it relates to the entire drug discovery, development, and manufacturing sequence (Felton, 2013). Metrology in chemistry is an essential foundation of analytical chemistry. The metrological approach to handle chemical information is essential for the future of analytical chemistry, especially in the Big Data Era (Valcarcel & Lendl, 2004; Merone et al., 2020; Adams & Adriaens, 2020). Metrology is the science of measurement and its application. Metrology includes all theoretical and practical aspects of measurements, whatever the measurement uncertainty and field of application (Yagüe-Fabra, 2016).

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The analyst needs to know whether the result of measurement can be accepted with confidence or, on the contrary, rejected because it is wrong; whether an analysis method is suitable for the intended use; can the analyst trust a new developed method. The metrology, especially statistical tools and approaches, allow researchers to address all these points. (Belouafa et al., 2017). Metrological characteristics of methods and obtained results allow to carry out evaluation and comparison as experimental methods and research objects and on this basis to solve a number of applied problems (variety of method verification practices including instrument qualification and calibration, analytical method validation, system suitability testing, assays and quality control checks), which are so important in pharmaceutical industry (Ukrainian Scientific Pharmacopoeial Center for Quality of Medicines, 2022)<sup>1</sup>.

Given the importance of metrology in analytical chemistry and pharmacy, the elective course “Basics of chemical metrology” is designed for part-time students of the second year of study of the pharmaceutical faculty at Bogomolets National Medical University. The aims of this paper are to describe the curriculum of the elective course, its online form organizing, assess the attitude of students to the course and share practice in implementation of the course. The research objective is to assign the effectiveness of proposed design of the course during two academic years.

### Description of Elective Course

The online 3,0-credit hours elective course “Basics of chemical metrology” was offered during the first semester 2020-2021 and 2021-2022 academic years. There were three hundred and ninety four part-time students enrolled in this course during 2020-2021 academic year and two hundred and seventeen students enrolled in this course during 2021-2022 academic year (Tables 1, 2).

Table 1

Information about different streams of part-time students enrolled in the elective course “Basics of chemical metrology” during 2020-2021 academic year

Stream of students	Number of groups	Number of students	Session schedule
5.5 years of studying <sup>2</sup>	2	24	17.10–28.10
4.5 years of studying (“Medicine”) <sup>3</sup>	6	84	21.11–02.12
4.5 years of studying (second higher education) <sup>4</sup>	2	32	06.12–16.12
4.5 years of studying (“Pharmacy”) <sup>5</sup>	17	254	10.01–20.01
	<i>total 27</i>	<i>total 394</i>	

<sup>1</sup> The State Pharmacopoeia of Ukraine is a legal act that contains general requirement for medicinal products, pharmacopoeal chapters as well as medicine quality control procedures.

<sup>2</sup> Students who went directly to university after school.

<sup>3</sup> Students who went to university after medical college.

<sup>4</sup> Students who received a second higher education.

<sup>5</sup> Students who went to university after pharmacy college.

Table 2

Information about different streams of part-time students enrolled in the elective course “Basics of chemical metrology” during 2021-2022 academic year

Stream of students	Number of groups	Number of students	Session schedule
4.5 years of studying (“Pharmacy”)	11	160	14.11–24.11
4.5 years of studying (“Medicine”)	4	43	20.11–01.12
4.5 years of studying (second higher education)	1	14	05.12–15.12

The course consisted of three lectures (three hours), three seminars (six hours) and independent work of students (eighty one hours). The information about the course topics and distribution of the hours between them is presented in Table 3.

Table 3

Structure of the elective course “Basics of chemical metrology”

Topic	Number of hours			
	total	lectures	seminars	individual work of students
Basics of metrology. Metrological support of analysis.	32	2	2	28
Statistical analysis of results of chemical experiments in accordance with the requirements of State Pharmacopoeia of Ukraine.	29	1	2	26
Mathematical statistics and theory of probability.	29	–	2	27
<i>Total hours</i>	<i>90</i>	<i>3</i>	<i>6</i>	<i>81</i>

According to the curriculum, seminars provided for the formation of such students’ knowledge, skills and abilities of performing calculations of the main metrological parameters of the chemical analysis in accordance with the requirements of the State Pharmacopoeia of Ukraine; performing statistical processing of experimental results and operate with mathematical methods; interpret and evaluate the results of drug analysis in accordance with the requirements of the State Pharmacopoeia of Ukraine.

Final mark consisted of two parts: mark for control work (minimum points 72 and maximum points 120) and mark for current control during the seminars (maximum points 80). The control work consisted of six tasks (two tasks for each topic). The student received the tasks of control work at the end of the summer session on the first year of study and the student was obliged to return it to his teacher for verification no later than a month before the start of the winter session on the second year of study. The teacher had the right to return the control work to the student for revision.

## METHOD

### Organizing Online Course

Online form and blended form of education were adopted in Bogomolets National Medical University due to the COVID-19 pandemic in 2020-2021 and 2021-2022 academic years for part-time students. Bogomolets National Medical University has implemented the platform LIKAR\_NMU (Bogomolets National Medical University (n.d.)) on the basis of Learning Management Systems Moodle for distance education (Makruf et al., 2022, Pushkarova et al., 2021; Reva et al., 2021; Toraman, 2021; Ünal, 2021).

The using portal LIKAR\_NMU allows creating a well-structured teacher-student interaction. All useful materials were posted on a web-based learning platform LIKAR\_NMU and available for students (Figure 1):

- block “general information about the course” includes pdf-files of curriculum of the course, syllabus of the course, regulations and criteria for evaluating the current control and differential credit;
- block “recommended literature” includes pdf-files of useful books and articles for studying the course;
- block “lectures” includes PowerPoint presentations of lectures and pre-recorded video lectures;
- block “seminars” includes methodological instructions with complete information about the seminars and tasks for estimation the students’ knowledge.

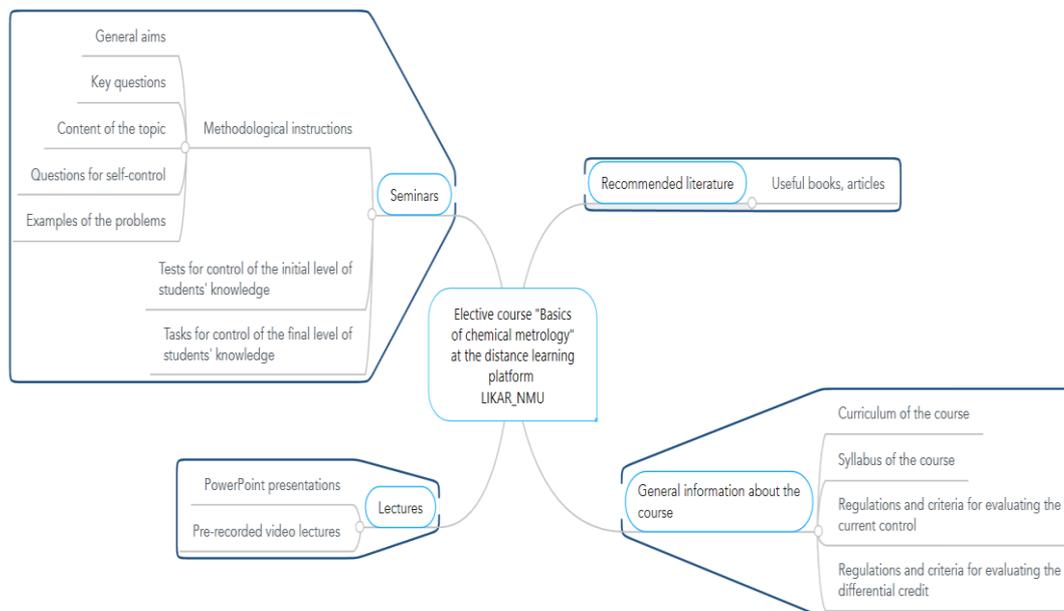


Figure 1  
Structure of the discipline “Basics of chemical metrology” at the distance learning platform LIKAR\_NMU

The posted materials on platform LIKAR\_NMU we hope were provided to enhance students' understanding of the course (Cahyana et al., 2019; Ziden & Rahman, 2013).

Each lecture and seminar (according to the schedule) were occurred like videoconference via Zoom. Organizational structure of each seminar is presented in Table 4. Duration of each seminar is 90 minutes. Out-class activity of the students includes reading of recommended literature and articles, performing the control work, performing the tasks for individual work of students (according to the curriculum of discipline), studying the lectures’ material.

Table 4

Organizational structure of the seminar		
Stages of the seminar	Time distribution	In-class activity
Preparatory stage	20 min.	
Organizational issues	5 min.	
Formation of motivation	5 min.	Discussion the actuality of the topic
Control of the initial level of students' knowledge	10 min.	10 test questions
Main stage	45 min.	
Study of the topic		Discussion the key questions according to the topic of seminar, answering the students' questions, consideration of calculated and situational problems
Final stage	25 min.	
Control of the final level of students' knowledge	15 min.	Solving the one complex problem
Overall results. Assigning marks	10 min.	

### Case Studies

Due to the fact that three seminars and three lectures are not enough to study chemical metrology it was necessary to acquaint the part-time students of pharmaceutical faculty with the most important aspects of chemical metrology for pharmacy. Therefore, the teachers tried to choose the tasks as content of designed course that will be most useful for future pharmacists. So, the main questions which are considered during the lectures and seminars are:

- 1) specifics of chemical analysis as a metrological discipline;
- 2) general metrological characteristics of chemical analysis (mean, variance, standard deviation, standard deviation of the mean, relative standard deviation, relative variance, relative standard deviation of the mean, confidence interval);
- 3) quantity of significant numbers in the final result;
- 4) errors in chemical analysis and their classification;
- 5) homogeneity of the sample;
- 6) presence of a significant systematic error;
- 7) basic concepts of validation of analytical methods and tests;
- 8) reproducibility and repeatability of the results of chemical analysis;
- 9) basic probability concepts as base for studying binomial distribution and Poisson distribution, which are the most important for pharmacy analysis.

The following case study examples were directly extracted from lecture notes and seminar notes.

#### Case study 1

Results of standardization of potassium permanganate solution using oxalic acid solution as primary standard ( $\text{mole/dm}^3$ ) are: 0.1250; 0.1255; 0.1265; 0.1260; 0.1245. Process the data, namely: verify the homogeneity of the results; determine the confidence interval (95% confidence level); determine the quantity of significant numbers in the final result.

#### Case study 2

Quality control of the some drug "A" (active substance of metoprolol tartrate) includes the spectrophotometric determination of metoprolol tartrate. According to the regulatory documentation, the content of the active substance should vary from 95.0 to 105.0 mg. The following results were

obtained from the five parallel determinations, mg: 96.74; 96.88; 97.0; 97.36; 98.43. Perform the statistical analysis of the given results at the 95% confidence level and estimate their repeatability.

#### *Case study 3*

According to the regulatory documentation, the content of metamizole sodium in the some drug “A” is carried out by iodometric titration. For metrological certification of a new titrimetric method for the metamizole sodium determination in the drug “B”, a sample containing 503.00 mg of metamizole sodium was analyzed. The following results were obtained from the ten parallel determinations, mg: 498.73; 505.23; 509.42; 509.52; 513.12; 523.84; 524.41; 525.31; 534.89; 537.30. Check the presence of the significant systematic error of the titrimetric method at the 95% confidence level.

#### *Case study 4*

The some drug “A” in powder form for suspension for internal use was analyzed by fluorimetry for determination of the content of impurities – clavulanate polymer. Its amount should not exceed 5.5% of the declared content of clavulanic acid. The following results were obtained from the three parallel determinations of the clavulanate polymer, %: 5.12; 5.16; 5.21. Estimate the repeatability of the obtained results at the level 95% confidence level.

#### *Case study 5*

It is known that one of the pharmacopoeia criteria of drug quality is the indicator of dosage uniformity. Traditionally, the drugs analysis of the dosage uniformity is carried out by high-performance liquid chromatography, gas chromatography and ultraviolet-visible spectrophotometry, etc. Near-infrared spectroscopy is an alternative, fast, convenient method of analysis of dosage uniformity, but its implementation requires a validation procedure. In order to assess the reproducibility and correctness of the new method of near-infrared spectrometry, the analysis of some drug “A” for dosage uniformity is carried out by two methods: ultraviolet-visible spectrophotometry (method I) and near-infrared spectrometry (method II). It is known that the method of ultraviolet-visible spectrophotometry is metrological certified, so does not contain systematic errors. The results of determination of chloropyramine hydrochloride content in tablets “A” by two methods are, mg/tablet:

1) 26.22; 26.49; 26.55; 26.55; 26.65; 26.76; 26.83; 26.85; 27.08; 27.60;

2) 26.15; 26.40; 26.56; 26.56; 26.67; 26.68; 26.72; 26.77; 26.95; 27.43.

Compare of two methods of analysis by reproducibility at the 95% confidence level.

#### *Case study 6 (funny case)*

The chef have prepared 160 cupcakes using 10 kg of dough and 300 raisins. What is the probability that one randomly selected cupcake will not have any raisin?

### **Data Collection Procedures**

The quality of the course was assessed on an agree/disagree scale according to six-question post-course survey. The questionnaire was distributed by the authors through email to the part-time students of both 2020-2021 and 2021-2022 academic years. Microsoft Excel was used for analyzing survey results.

The reasons for the decline in the quality of education in 2021-2022 academic years in comparison with 2020-2021 academic year were identified on additional interviewing of part-time students of 2021-2022 academic year. The authors asked the students answer the open-ended question: “How you can explain the decline in the quality of education in 2021-2022 academic years in comparison with 2020-2021 academic year? Name the important reason/reasons”.

## FINDINGS AND DISCUSSIONS

Three hundred and ninety four part-time students completed this online course in 2020-2021 academic year and two hundred and seventeen part-time students completed the online course in 2021-2022 academic year. Number of students who received grades of A, B, C, D or E are shown in Tables 5 and 6. Information about average score (maximum 5.0) is also presented in above-mentioned Tables.

Table 5

The grades achieved in the online course during 2020-2021 academic year

Stream of students	Grade					Average score
	A (%)	B (%)	C (%)	D (%)	E (%)	
5.5 years of studying	17 (70.9%)	2 (8.3%)	2 (8.3%)	1 (4.2%)	2 (8.3%)	4.58
4.5 years of studying ("Medicine")	13 (15.6%)	30 (35.7%)	27 (32.1%)	6 (7.1%)	8 (9.5%)	3.99
4.5 years of studying (second higher education)	17 (53.1%)	10 (31.3%)	2 (6.2%)	–	3 (9.4%)	4.44
4.5 years of studying ("Pharmacy")	17 (6.7%)	73 (28.7%)	133 (52.4%)	22 (8.7%)	9 (2.5%)	3.94
	<i>total 64</i> (16.2%)	<i>total 115</i> (29.2%)	<i>total 164</i> (41.6%)	<i>total 29</i> (7.4%)	<i>total 22</i> (5.6%)	<i>4.03</i>

Table 6

The grades achieved in the online course during 2021-2022 academic year

Stream of students	Grade					Average score
	A (%)	B (%)	C (%)	D (%)	E (%)	
4.5 years of studying ("Medicine")	–	7 (16.3%)	25 (58.1%)	9 (20.9%)	2 (4.7%)	3.74
4.5 years of studying (second higher education)	2 (14.3%)	–	12 (85.7%)	–	–	4.14
4.5 years of studying ("Pharmacy")	11 (6.9%)	27 (16.9%)	54 (33.7%)	24 (15.0%)	44 (27.5%)	3.64
	<i>total 13</i> (6.0%)	<i>total 34</i> (15.7%)	<i>total 91</i> (41.9%)	<i>total 33</i> (15.2%)	<i>total 46</i> (21.2%)	<i>3.70</i>

Most students earned grades C and B. As one can see, phenomenon of moderate decreasing of the quality of education is occurred in 2021-2022 academic year in comparison with 2020-2021 academic year: decreasing the percentage of students, who received grades A, B and increasing the percentage of students, who receive grades D or E, as well as decreasing the average score from 4.03 till 3.70.

As a result of an interview of students, we can identify three main reasons for the decline in the quality of education:

- 1) "psychological fatigue" (stress, anxiety, depression) due to the COVID-19 pandemic;
- 2) problems with employment during the pandemic;
- 3) difficulty in balancing learning with work, family and other personal commitments.

The aim of the present study was also to evaluate the attitude of students to the course and assess the effectiveness of pre-recorded video lectures for part-time students education. All three lectures is occurred like videoconference via Zoom according to the schedule. And pre-recorded video lectures were posted on a web-based learning platform LIKAR\_NMU and available for students. Lecturers use PowerPoint with the voiceover feature for creating pre-recorded video lectures. PowerPoint with voiceover is a tool that allows us to provide voice explanations of examples, tables, facts, graphs, etc. The final result was being saved as a video in the mp4 file format.

We developed the post-course survey, which statements are listed in Table 7. Three hundred and one part-time students (76.4%) completed this post-course survey in 2020-2021 academic year, one hundred and forty four part-time students (66.4%) completed this post-course survey in 2021-2022 academic year.

Table 7  
Results of course “Basics of chemical metrology” evaluation survey

Question	Students response 2020-2021 academic year / 2021-2022 academic year		
	Agree/strongly agree, n (%)	Neither agree nor disagree, n (%)	Disagree/strongly disagree, n (%)
The course increased your interest in chemical metrology	152 (50.5%) / 76 (52.8%)	121 (40.2%) / 53 (36.8%)	28 (9.3%) / 15 (10.4%)
The case studies were effective and useful for understanding the role and application of chemical metrology in pharmacy	199 (66.1%) / 86 (59.7%)	77 (25.6%) / 39 (27.1%)	25 (8.3%) / 19 (13.2%)
Course is with effective delivery of material	214 (71.1%) / 99 (68.8%)	73 (24.3%) / 36 (25.0%)	14 (4.6%) / 9 (6.2%)
The online course is well organized	212 (70.4%) / 92 (63.9%)	75 (24.9%) / 45 (31.2%)	14 (4.7%) / 7 (4.9%)
Pre-recorded video lectures are useful for repeating the material and preparation to seminars	221 (73.4%) / 97 (67.4%)	62 (20.6%) / 34 (23.6%)	18 (6.0%) / 13 (9.0%)
I would recommend this elective course to other students	188 (62.4%) / 87 (60.4%)	70 (23.3%) / 47 (32.7%)	43 (14.3%) / 10 (6.9%)

Most of part-time students reported that they would recommend this elective course to other students. Overall, students felt that the course was well-organized with effective delivery of material and useful case studies. Also most of part-time students agreed, that pre-recorded video lectures are useful for repeating the material and preparation to seminars. This coincides with our opinion. Initially, we have made pre-recorded video lectures for part-time students who, for good reasons, will not be able to attend online lectures via Zoom. But during the course we understood that most of part-time students have also used them for preparation to seminars.

The our future plans are to design and extend (increase the number of hours for lectures and seminars) this elective course for full-time national and foreign (English-speaking) students of the second year of study of the pharmaceutical faculty at the Bogomolets National Medical University.

## CONCLUSION

The relevance of chemical metrology to pharmacy practice is not apparent to most pharmacy students. The pharmacy case studies presented in this work illustrated that the chemical metrology is the important section of analytical chemistry, and metrological control and processing of results of chemical analysis is a necessary step in solving any quantitative analysis task and so the same time very important for pharmaceutical analysis of drugs and substances. These case studies gave the part-time pharmacy students an insight into the different roles of the chemical metrology in pharmacy industry. The survey results shows that the interest in chemical metrology increased among more than half of the part-time students (only 50.5 % in 2020-2021 academic year and 52.5 % in 2021-2022 academic year), but we consider this fact as our achievement. Most of the students, were involved in the case studies solving process despite the large number of students in each group.

The online elective course “Basics in chemical metrology” was successfully implemented during the first semester of 2020-2021 and 2021-2022 academic years for pharmacy part-time students of the second year of study at the Bogomolets National Medical University. The distance learning platform LIKAR\_NMU on the basis of LMS Moodle together with video conferencing via Zoom and pre-recorded video lectures were used for its realization. Our data indicate that most pharmacy part-time students earned grades C and B. This sufficient high level of the students’ performance confirms that the online elective course was successfully conducted achieving the desired learning outcomes. The structure of the course proposed in the article is informative for studying the basics of chemical metrology. Case studies is recommended as effective instructional method for teaching short elective courses. Based on the results, the suggestion is to apply for teaching the part-time students pre-recorded video lectures as useful tool that can improve students’ knowledge and skills.

In the future studies, it would be interesting to design and extend the same course for full-time pharmacy students.

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