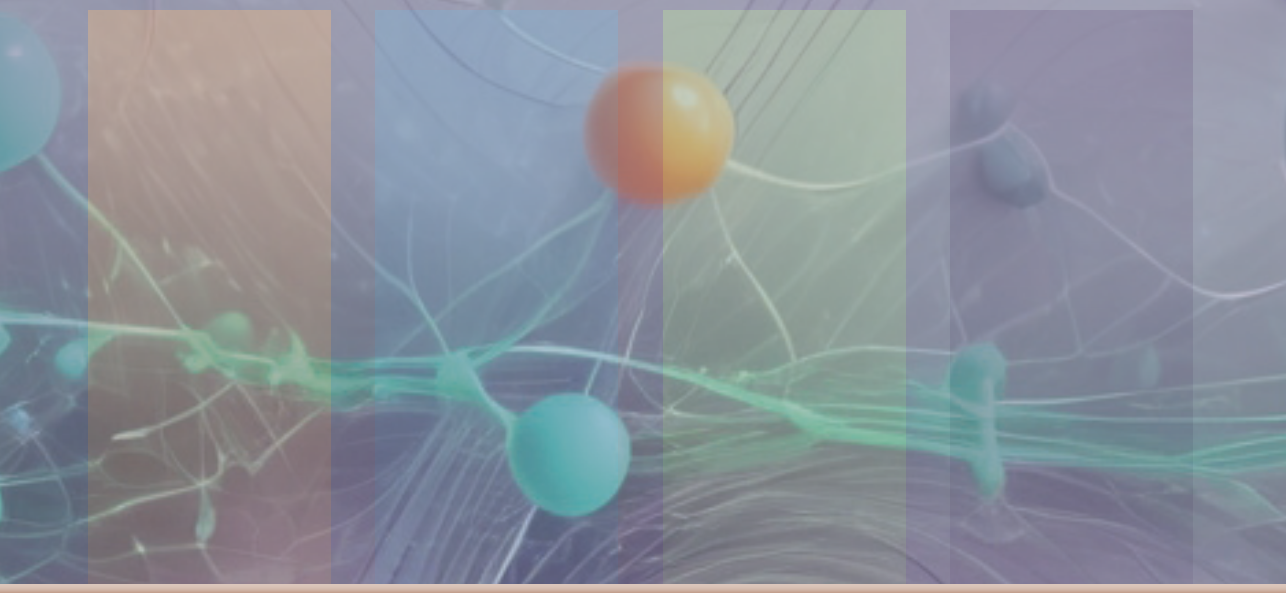
Sherman Oaks California (USA), 2025



MODERN ASPECTS OF SCIENCE AND EDUCATION

COLLECTIVE MONOGRAPH

MODERN ASPECTS OF SCIENCE AND EDUCATION

Compiled by
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GS Publishing Services
Sherman Oaks
2025

The collective monograph is a scientific and practical publication that contains scientific articles by doctors and candidates of sciences, doctors of philosophy and art, graduate students, students, researchers and practitioners from European and other countries. The articles contain research that reflects current processes and trends in world science.

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MEDICAL-PSYCHOLOGICAL, ENVIRONMENTAL AND SOCIO-ECONOMIC CONSEQUENCES OF THE CHORNOBYL DISASTER
based on the materials of the scientific and practical online conference with international participation April 25, 2025

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MEDICINE AND PHARMACY: CURRENT ISSUES OF GENERAL MEDICAL AND PHARMACEUTICAL PRACTICE IN WAR TIMES
based on the materials of the scientific and practical online conference with international participation on May 14, 2025

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Publisher «GS Publishing Services»
15137 Magnolia Blvd, # D,
Sherman Oaks, CA 91403, USA.

ISBN 979-8-9917519-2-6
DOI: 10.51587/9798-9917-51926-2025-023

Scientific editors-reviewers:
S. Bobrovnyk, Yu. Bondar, A. Cherep, P. Glukhovskiy, P. Hovorov, Yu. Kuznetsov, V. Lazurenko, V. Moiseienko, L. Omelianchyk, R. Protsiuk, Zh. Virna.

The monograph is recommended for publication by the Academic Council of the Institute of Adult Education, Presidium of the National Academy of Sciences of Higher Education of Ukraine.

Modern aspects of science and education : collective monograph / Compiled by V. Shpak; Chairman of the Editorial Board S. Tabachnikov. Sherman Oaks, California : GS Publishing Services, 2025. 428 p.

Available at: DOI: 10.51587/9798-9917-51926-2025-023

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MEDICINE AND PHARMACY: CURRENT ISSUES OF GENERAL MEDICAL AND PHARMACEUTICAL PRACTICE IN WAR TIMES

based on the materials of the scientific and practical online conference with international participation on May 14, 2025

ження дисципліни «Основи патентознавства» з урахуванням освітніх, інституційних та мотиваційних аспектів сприятиме підготовці фахівців, здатних ефективно захищати та комерціалізувати свої ідеї. Адаптація світового досвіду та забезпечення доступу до необхідних ресурсів є ключовими факторами успішної реалізації цього завдання.

Навчальна дисципліна «Основи патентознавства» має зайняти вагоме місце у структурі сучасної вищої освіти, особливо у медичних та фармацевтичних закладах вищої освіти. Системне викладання основ патентознавства сприятиме не лише захисту інтелектуальної власності, а й розвитку творчого, інноваційного мислення в українському студентстві. Через вивчення дисципліни «Основи патентознавства» майбутні фахівці отримують ключові інструменти для забезпечення правового захисту результатів наукової діяльності та сприяння зростанню конкурентоспроможності національної науки.

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COMPETENCY-BASED APPROACH TO TEACHING PHYSICO-CHEMICAL METHODS OF ANALYSIS IN MODERN PHARMACEUTICAL EDUCATION

Medical professionals must be prepared to work with new medical and technical devices, understand current trends in societal change and, accordingly, new healthcare priorities, such as population aging, military conflicts, and pandemics. Currently, pharmaceutical education does not meet the above-defined tasks, and health care systems lag behind the modern needs

of the population. Among the reasons leading to this lag, one can mention the focus of classical teaching methods on theory, pharmaceutical analysis and physico-chemical methods, on technical skills, without a broader contextual understanding of the requirements and the acquisition of the necessary competencies that meet the needs of society.

It is believed that competency-based education (CBE) can provide specialists with the necessary prerequisites for participation in patient- and population-oriented health care. Modern pharmaceutical education has to shift from traditional knowledge-based instruction to CBE[1]. The importance of physicochemical methods of analysis in pharmaceutical education.

The physico-chemical methods of analysis are foundational to pharmaceutical education, ensuring that graduates possess not only theoretical knowledge but also the practical skills necessary to perform accurate and reliable analyses. It is essential for training specialists capable of ensuring the quality, safety, and efficacy of medicinal products. They allow students to master techniques used for identification, quantitative determination, and study of the properties of pharmaceutical substances. This is particularly important in the development of new drugs, monitoring their stability, and complying with pharmacopeia standards.

Furthermore, knowledge of physico-chemical methods of analysis helps future pharmacists understand the processes of production, standardization, and certification of medicinal products. They learn to conduct spectroscopic, chromatographic, and electrochemical studies necessary to confirm the composition and purity of drugs. Thus, analytical methods become the foundation for scientific research, quality control, and the practical activities of pharmaceutical industry specialists.

The competency-based approach ensures that students acquire specific, measurable skills that align with both academic standards and professional expectations[2].

The Essence of Competency-Based Education

The competency-based approach is a teaching method that focuses not only on the transmission of knowledge but also on the development of practical skills,

1 McMullen J., Arakawa N., Anderson C., Pattison L., McGrath S. (2023). A systematic review of contemporary competency-based education and training for pharmacy practitioners and students, Research in Social and Administrative Pharmacy, 19(2), 192-217, https://doi.org/10.1016/j.sapharm.2022.09.013.

2 Frank, J. R., Snell, L. S., Cate, O. T., et al. (2010). Competency-based medical education: theory to practice. Medical Teacher, 32(8), 638–645. DOI: https://doi.org/10.3109/0142159X.2010.501190

abilities, and personal qualities necessary for professional activities. Unlike the traditional approach, which emphasizes memorization, the competency-based approach aims to develop the ability to apply knowledge in real situations, think critically, solve problems, and adapt to new challenges.

In pharmaceutical education, this approach is particularly important because future specialists must not only understand the theory but also be able to analyze medicinal products, interpret research results, comply with standards, and act in the best interests of patients. It prepares students for real work by teaching them how to apply physico-chemical methods of analysis in practical pharmacy, scientific research, and pharmaceutical production.

Competency-based education emphasizes learning outcomes and the demonstration of competencies rather than time spent in the classroom. This paradigm aligns with global trends in medical and pharmaceutical education aimed at producing professionals who can apply their knowledge in real-world scenarios. CBE involves clearly defined outcomes, systematic learning paths, and rigorous assessment strategies.

The integration of CBE in pharmaceutical education fosters critical thinking, problem-solving, and analytical abilities, which are particularly vital in courses involving physico-chemical analysis. Additionally, CBE promotes self-directed learning and encourages students to actively participate in shaping their educational experiences.

Global and Ukrainian Perspectives on CBE

Globally, institutions have increasingly adopted CBE frameworks to align curricula with the demands of modern healthcare[3]. A similar trend is observed in Brazil, where the Brazilian Ministry of Education, together with the Ministry of Health, are currently developing the curricula for pharmaceutical students based on the competency-based approach[4]. Particularly the Ministry of Education's guidelines emphasize socio-scientific integration and practical competencies[5]. Similarly, Finnish

3 Silva, C. C., & Mortimer, E. F. (2019). Competency-Based Chemistry Education in Brazil: A Case of Socio-Scientific Curriculum Integration. Science Education International, 30(4), 259–267; Rocha, K. V., Vasconcelos, M. D. A., & dos Santos, R. C. (2019). Socio-scientific issues and chemistry education: A view from Brazilian teachers. Education and Science, 44(198), 1–22. https://doi.org/10.1590/educacaoeescolar2019-198

4 Reflexão sobre o ensino farmacêutico. URL: https://repositorio.unesp.br/entities/publication/f91178b6-93bf-47b8-a4b9-a246d07a2c9b; Competency-based education in pharmacy and pharmaceutical sciences. URL: https://www.fip.org/file/5338.

5 Brazil, Ministry of Education. (2018). National Curriculum Guidelines for Higher Education in Chemistry (Diretrizes Curriculares Nacionais).

higher education incorporates core curricula rooted in competencies, ensuring alignment with labor market needs[6]. These international models offer examples of how CBE can support professional development while maintaining academic rigor.

In Ukraine, the movement toward competency-based models is also gaining traction. Information technologies play a key role in enhancing the effectiveness of teaching analytical chemistry, aligning with modern pedagogical demands[7]. Research[8] demonstrates how CBE frameworks enhance research skills in pharmaceutical education. Moreover, authors[9] underlines the foundational role of analytical chemistry in pharmaceutical curricula, providing theoretical underpinnings for competency development. National initiatives and academic conferences, such as the one highlighted by authors[10], emphasize the importance of innovative teaching approaches in a computer-oriented environment. Further, the Ukrainian scientific community is increasingly recognizing the value of international collaborations and digital tools as part of modern educational reforms.

Disadvantages of traditional methods of teaching physical and chemical methods of analysis in pharmaceutical education

Until now, the teaching of physico-chemical analysis methods in pharmaceutical education has been based on classical pedagogical approaches. The main traditional methods include:

- Lectures, where students received theoretical information about analysis methods, the principles of equipment operation, and data interpretation.
- Practical classes in specially equipped laboratories where students allowed to familiarize themselves with some instrumental analysis techniques and develop basic experimental skills. Occasionally, students were able to work with instruments such as spectrometers and potentiometers.
- Seminars and Group Work for discussion of theoretical aspects, analysis of real-world problems, and examples from pharmaceutical practice.

6 Finnish National Agency for Education (EDUFI). (2016). National Core Curricula for Higher Education.

7 Pushkarova, Y., Chkhalo, O., Reva, T., Zaitseva, G., & Bolotnikova, A. (2021). Using Information Technology in Teaching of the Course «Analytical Chemistry» in Bogomolets National Medical University. Archives of Pharmacy Practice, 12(3), 89–93. URL: https://doi.org/10.51847/dvMCSbO1SE.

8 Zaitseva, G. M., Stuchynska, N. V., & Pushkaryova, Y. M. (2024). Formation of Research Skills in Future Pharmacists. Medicine and Pharmacy: Educational Discourses, (2), 16–19. DOI: https://doi.org/10.32782/eddiscourses/2024-2-3.

9 Fediushchak, N. K., et al.(2012). Analytical Chemistry. Vinnytsia: Nova Knyha.

10 Kalibabchuk, V. O., et al. (2022). Innovative Technologies in Teaching Chemistry Disciplines in Higher Medical Educational Institutions in a Computer-Oriented Educational Environment. VIII Scientific Conference.

The traditional system of teaching physico-chemical analysis methods, despite its thoroughness, faces several limitations, especially in the context of rapid technological advancements:

• Limited Personalization Opportunities.

Traditional teaching methods do not always consider students' individual needs. Lectures and laboratory classes are conducted in a uniform format for everyone, without adaptation to different levels of preparation or learning styles

• Restricted Access to Modern Equipment

Many universities struggle to update laboratories and acquire expensive analytical equipment. As a result, students may learn theoretical aspects of analysis methods but lack the opportunity to apply them fully.

• Limited Practical Training

Laboratory work generally requires students to be physically present in the classroom, reducing the flexibility of education. Moreover, the number of practical hours is often insufficient for mastering complex analytical techniques.

• Insufficient Integration of an Interdisciplinary Approach.

Physico-chemical analysis methods are closely connected with biotechnology, pharmaceutical chemistry, and digital data processing. However, traditional teaching systems provide minimal interaction between these disciplines.

• Difficulties in Learning Big Data Processing

Modern pharmaceutical analytics increasingly uses big data processing and predictive algorithms, which are not always incorporated into curricula. As a result, graduates may not be fully prepared to work with digital tools.

These limitations highlight the need for modernization in education. This is where artificial intelligence and new technologies can play a key role, but it requires rethinking teaching approaches.

Teaching Physico-Chemical Methods through CBE

Physico-chemical methods of analysis, including spectroscopy, chromatography, and electrochemical techniques, require a deep understanding of theory and proficiency in laboratory skills. CBE enables educators to design modules that focus on mastering each of these competencies through iterative practice and assessment. According to the ACS Guidelines[11], effective teaching in chemistry must be competency-focused, highlighting laboratory proficiency, data interpretation, and ethical standards.

11 American Chemical Society. (2015). ACS Guidelines and Evaluation Procedures for Bachelor's Degree Programs.

Innovative strategies such as problem-based learning (PBL), flipped classrooms, and digital simulation platforms enhance students' engagement and mastery of complex analytical techniques. A study by PUC-Rio Academic Innovation Office[12] reports successful implementation of such models in chemistry and chemical engineering education.

One example of integrating CBE into the teaching of physico-chemical methods is the use of capstone projects that simulate real pharmaceutical industry challenges. These projects help students link their academic learning with future workplace demands. Collaborative assignments that mimic laboratory teamwork further enhance soft skills such as communication, leadership, and time management, all of which are essential competencies in the pharmaceutical field.

Digital Transformation

Digital transformation is revolutionizing the teaching of instrumental analysis in pharmaceutical education, making it more interactive and fostering a deeper understanding of complex concepts through modern digital tools. Commonly the following aspects in which artificial intelligence (AI) can lead to significant progress in education is highlighted:

1. Simplification and Acceleration of Data Processing. AI can analyze vast amounts of data, identify patterns, and predict outcomes with high accuracy. This enables students to quickly master analytical information processing methods and reduces the time required for laboratory research.
2. Personalized Learning. Traditional teaching methods offer a uniform format for all students. AI, however, can adapt educational materials to individual needs, providing more flexible programs based on students' knowledge levels and interests.
3. Virtual Laboratories and Simulations. AI-powered interactive virtual laboratories allow students to conduct analyses in a digital environment, simulating real experimental conditions. This expands access to practical learning, especially in situations where physical laboratories are unavailable.
4. Automation of Routine Processes. AI can handle standard procedures such as spectral analysis, chromatographic data processing, and result

12 PUC-Rio Academic Innovation Office. (2020). *Relatório de práticas de ensino por competências nos cursos de química e engenharia química*

interpretation, freeing up time for students and instructors to focus on deeper methodological study.

5. Enhancing Interdisciplinary Learning. AI facilitates closer connections between analytical methods, data processing, bioinformatics, and pharmaceutical engineering, promoting a more comprehensive approach to education.

As noted by Pushkarova et al[13], integrating ICT into analytical chemistry fosters personalized learning and continuous feedback. Additionally, competency-based models benefit from data-driven learning and digital literacy. Learning management systems (LMS), online quizzes, real-time data analytics, and AI-powered tutoring systems are becoming indispensable tools in this transformation.

Moreover, interdisciplinary integration is critical[14]. Competency development in physico-chemical methods often intersects with courses in biology, pharmacology, and data science. Silva and Mortimer[15] advocate for a socio-scientific curriculum, promoting relevance and applicability of chemistry in real-life contexts. This integration equips future pharmacists with comprehensive analytical skills and ethical reasoning. Developing cross-disciplinary modules that include elements of environmental safety, toxicology, and pharmacokinetics enhances both the relevance and depth of physico-chemical analysis education.

Possible challenges and limitations

The introduction of the CBE system in pharmaceutical education requires significant changes and adaptation of curricula, training of teachers in new technologies and addressing ethical issues related to the use of CBE and AI methods. In particular, it is necessary to include courses on the use of AI in pharmaceutical analysis, add modules on data processing, machine learning and digital technologies, and train students

13 Brazil, Ministry of Education. (2018). National Curriculum Guidelines for Higher Education in Chemistry (Diretrizes Curriculares Nacionais).

14 Silva, C. C., & Mortimer, E. F. (2019). Competency-Based Chemistry Education in Brazil: A Case of Socio-Scientific Curriculum Integration. Science Education International, 30(4), 259–267; Pushkarova, Y., Chkhalo, O., Reva, T., Zaitseva, G., & Bolotnikova, A. (2021). Using Information Technology in Teaching of the Course "Analytical Chemistry" in Bogomolets National Medical University. Archives of Pharmacy Practice, 12(3), 89–93. https://doi.org/10.51847/dvMCSbO1SE; Rhoney D.H. et al, (2024). Evaluating the Need for Competency-Based Pharmacy Education (CBPE): The Report of the 2023–2024 Academic Affairs Standing Committee, American Journal of Pharmaceutical Education,88(8), https://doi.org/10.1016/j.ajpe.2024.100728.

15 Silva, C. C., & Mortimer, E. F. (2019). Competency-Based Chemistry Education in Brazil: A Case of Socio-Scientific Curriculum Integration. Science Education International, 30(4), 259–267.

in the interpretation of automated analytical results. It is necessary to improve the qualifications of teachers in the field of digital technologies, and to develop an interdisciplinary approach that combines pharmaceutical analysis, bioinformatics and programming. The integration of AI into the educational process will allow the use of virtual laboratories and simulations to model experiments. It will be possible to create intelligent assistants and chatbots for consultations on analysis methods. There is an opportunity to personalize the educational process, adapting materials to the student's level of knowledge.

Also promising is the possibility of conducting online experiments and remote workshops, using cloud platforms for joint data analysis and exchange of research results between different groups of students, between universities located in the same and even different countries. These changes will help create a more flexible, technological and future-oriented teaching system. Thus, the competency-based approach will include not only classical knowledge, but also modern digital tools, providing graduates with relevant skills for work in the pharmaceutical industry.

In this regard, special attention should be paid to ethical and organizational aspects, namely: Defining the boundaries of the use of AI in education, issues of trust in automated analysis systems, protecting student data and maintaining academic standards.

Assessment and Evaluation in CBE

One of the hallmarks of CBE is robust assessment. Unlike traditional models that often rely on summative examinations, CBE promotes continuous, formative assessments that provide feedback and guide learning. In the context of physico-chemical methods, assessments might include lab reports, practical demonstrations, peer reviews, and digital portfolios.

Assessment tools should be relevant to the identified competencies and accurately reflect the student's ability to perform specific tasks. To achieve this, it is advisable to use structured rubrics and milestone-based assessments to monitor progress in acquiring competencies. In addition, assessments should include affective and psychomotor domains along with cognitive outcomes.

Another innovative practice includes the use of OSCEs (Objective Structured Clinical Examinations), adapted for laboratory and analytical skills. These

examinations, combined with peer assessment and reflective journals, create a comprehensive picture of a student's competency development. Furthermore, e-portfolios allow students to document their progress and reflect on their learning journey.

Challenges and Future Directions

Despite its advantages, implementing CBE poses several challenges. These include resistance to change among faculty, the need for comprehensive curriculum redesign, and the demand for new assessment tools. Nevertheless, the opportunities far outweigh the barriers. Institutions that adopt CBE can produce graduates who are better prepared for professional roles, thus enhancing their employability and effectiveness in the pharmaceutical sector. Here are some recent examples of the successful use of CBE:

1. Belmont College of Pharmacy & Health Sciences allows the students to use AI to create tutorials and analyze research data and thus created Virtual labs. This helps them develop the skills needed for real-world lab work16.
2. At the University of Florida College of Pharmacy, CBE applied to provide personalized learning for students. AI was used to tailor curricula to individual student needs, improving learning[16].
3. The International Pharmaceutical Federation (FIP) released a comprehensive report on a Global Digital Health Education Framework, demonstrating global initiatives that integrate digital health into pharmacy education and into the pharmacy workforce and utilized a survey to understand what opportunities already existed[17].
4. International Pharmaceutical Federation has developed guidelines for implementing a competency-based approach in pharmaceutical education, which helps university's structure curricula and assess students' competencies[18].
5. Utrecht University has developed a process for implementing a competency-based approach, which includes defining learning goals, choosing assessment methods and creating a learning environment[19].

16 Prescriptions for Progress: How Pharmacy Education is Using AI (2025) https://news.ashp.org/News/ashp-news/2025/03/03/prescriptions-for-progress-ai-in-pharmacy-education

17 https://www.pharmacytimes.com/view/artificial-intelligence-applications-in-education-and-pharmacy-practice

18 International Pharmaceutical Federation (FIP). Competency-based education in pharmacy and pharmaceutical sciences, A FIP handbook to support implementation of competency-based education and training, Version 1, The Hague, FIP, 2022 https://www.fip.org/file/5338

19 Koster, A., Schalekamp, T., & Meijerman, I. (2017). Implementation of Competency-Based Pharmacy Education (CBPE). Pharmacy, 5(1), 10. https://doi.org/10.3390/pharmacy5010010

Conclusion

The competency-based approach is a forward-looking strategy that aligns pharmaceutical education with the needs of a modern, dynamic healthcare environment. By emphasizing demonstrable skills and real-world application, CBE enhances the teaching and learning of physico-chemical methods of analysis. As Ukrainian and international institutions continue to embrace this model, they pave the way for a more responsive, effective, and globally aligned educational system. Emphasizing lifelong learning, interdisciplinary integration, and digital innovation ensures that future pharmacists are well-equipped for the challenges and opportunities of the 21st-century pharmaceutical landscape.

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ХЕМОМЕТРИЧНІ МЕТОДИ У СУЧАСНІЙ ФАРМАЦІЇ

У фармацевтичній галузі хемометричні методи набувають дедалі більшого значення. Це алгоритми математичної та статистичної обробки даних, що дозволяють обґрунтовано аналізувати значні обсяги експериментальної інформації[1]. Їх застосування сприяє оптимізації процесів контролю якості, розробки нових лікарських форм та удосконаленню аналітичних методик[2]. Завдяки здатності виявляти приховані закономірності, будувати прогностичні моделі та зменшувати ви-

1 Холін, Ю. В., Пушкарьова, Я. М., Пантелеймонов, А. В., & Некос, А. Н. (2016). Хемометричні методи в розв'язанні задач якісного хімічного аналізу та класифікації фізико-хімічних даних.

2 Biancolillo, A., & Marini, F. (2018). Chemometric methods for spectroscopy-based pharmaceutical analysis. *Frontiers in chemistry*, 6, 576.