ANNOTATION

of the dissertation submitted for the degree of Philosophy Doctor (PhD) in the educational program 8D01504 - "Training of Chemistry Teacher" by Karmanova Aliya Sultankhanovna

Research topic: Development of professional competencies of future chemistry teachers based on digital technologies.

Relevance of the research. The current level of development of science and digital technologies requires students to acquire high-quality and in-depth knowledge and skills, to demonstrate active engagement, to engage in creative activity, to develop broad and flexible thinking. Under these conditions, the development of professional competencies of future teachers becomes particularly significant, as it ensures their readiness to work effectively within a dynamically changing educational environment. Considering the complexity and specificity of the academic subject "Chemistry", as well as the need to rely on fundamental scientific research and modern educational concepts, the development of professional competence is a key prerequisite for the high-quality training of future chemistry teachers. As an academic discipline, chemistry requires a deep understanding of subject content, the application of innovative teaching methods, and the active integration of digital technologies, which, in turn, presupposes a high level of professional competence of the teacher. The development of this competence enables future chemistry teachers to organize the educational process effectively, ensure the conscious acquisition of knowledge, and enhance students' sustained interest in mastering complex scientific concepts. Ultimately, this contributes not only to improving the quality of education but also has a positive impact on the development of science, industry, and society as a whole.

These requirements and trends are directly aligned with the strategic directions and regulatory documents of the education system of the Republic of Kazakhstan. In the 2023 Address to the Nation, the President of the Republic of Kazakhstan, K.K. Tokayev, emphasized that "one of the key factors of competitiveness in the modern world is maximum possible level of digitalization." In this regard, the digitalization of vocational education includes the implementation of innovative technologies that enhance the effictiveness of the educational process through the use of software.

In the context of educational digitalization, the state program "Digital Kazakhstan" emphasizes the need to increase digital literacy across secondary, technical, vocational and higher education levels. The "Kazakhstan-2050" Strategy also highlights the development of the education sector as one of the four key priorities, stating that "we must ensure the intensive introduction of innovative methods, solutions and tools into the national education system".

In the conditions of a digital society, higher education institutions are tasked with training specialists who possess modern professional knowledge and skills, a well-developed personal culture, competitiveness, and a high level of digital literacy. In this regard, the issue of developing the professional competence of future chemistry teachers through the use of digital technologies becomes particularly significant. The relevance of this issue was further enhanced by the adoption of the Law of the Republic of Kazakhstan "On the Status of Teachers" in December 2019, which introduced new requirements for teacher's functions, professional activities and competencies, thereby requiring a review of approaches to teacher education.

Today, one of the main requirements of society for graduates of pedagogical universities is the development of professional competencies. In his Address to the Nation, President Kassym-Jomart Tokayev has noted the need to reorient the entire vocational education system to the development of competencies that are in demand in the labor market. This indicates that ensuring high-quality training for educational institutions that train future specialists is a top priority.

The legal framework for addressing this issue by the Law of the Republic of Kazakhstan "On Education", the State Compulsory Education Standards of the Republic of Kazakhstan, the Professional Standard for Teachers, the National Report on Science, as well as other state regulatory documents, strategic programs and annual Addresses the President of the Republic of Kazakhstan to the people, including speeches delivered at the Gylym Ordasy.

Moreover, documents aimed at ensuring the high quality of world education regard the development of professional competencies of future teachers as one of the priority areas of education policy in many countries worldwide. For example, in 2018, the International Association for the Evaluation of Educational Achievements published the results of research conducted in 14 countries around the world, showing that the quality of education is directly depended on the level of professional qualification and competence of future teachers. Therefore, the development of professional competence of future teachers is an important task for ensuring high-quality education at the global level.

The Concept for the Development of Education and Science in the Republic of Kazakhstan for 2023–2029 outlines the need to expand the autonomy of higher education institutions, enhance knowledge and competency development, and design modern educational programs focused on advanced technologies, the economy of the future, and competency-based professional training. The document also notes the need to develop a new pedagogical learning design that incorporates elements of digital technologies. In addition, priority areas are identified that provide for the active use of modern trends in the training of future teachers.

The mentioned strategic and normative documents indicate an increasing demand for the development of both professional and digital competencies among future teachers, which necessitates a comprehensive scientific and

theoretical examination of this issue within the broader process of educational digitalization. In this regard, particular importance is attached to analyzing the essence, structure and mechanisms of development of the concepts of "competence" and "professional competence", including the specific features of their formation in the context of educational digitalization, as well as determining their role in pedagogical practice. It can be asserted that this issue represents a priority area of modern pedagogical and psychological research.

The issues outlined above have been extensively addressed in the works of both domestic and international scholars, where the theoretical foundations and practical aspects of the competency-based approach in education are explored from various scientific perspectives, including the ways of its implementation within a digital educational environment.

In the studies of scholars such as Sh. Taubayeva, K.S. Kudaibergenova, B.A. Turgunbayeva, S.A. Zholdasbekova, D.K. Poshaev, N.Sh. Almetov R. Arnold, G. Vlumenstein, J. Raven, K. Rogers, I.V. Robert, S. Whiddet, S. Hollyforde, P. Heine, V.A. Metaeva, N.N. Nechaev and others, the concepts “competence” and “competent” are examed from pedagogical and psychological perspectives.

The essence of the concepts “professional competence” and “professional competence of a future teacher” is analyzed in the research of B.T. Kenzhebekov, K.M. Berkimbayev, B.T. Ortaev, B.S. Omarov, K.V. Shaposhnikov, A.K. Markova, T.E. Isaeva, E.G. Zlotnikov, M.S. Pak, I.A. Orlova, M.K. Toletova, Y.Yu. Gavronskaya and other domestic and international scientists.

The issue of developing competence in improving the educational process, including the readiness of future specialists to use information technologies and the development of their information culture, has been studied from various scientific perspectives in the works of E.Y. Bidaybekov, D.M. Zhusupalieva, K.M. Berkimbayev, A. Sagymbayeva, B.T. Barsai, G.I. Beisenova, L.P. Abisheva, B.T. Kenzhebekov, S.M. Kenesbayev, B.A. Doszhanov, G.U. Syzdykbayeva, A.T. Chaklikova and other researchers.

Research addressing the development of students' competences through improving the methodology of teaching chemistry can be found in the works of I. Nugymanuly, Zh.A. Shokybayev, K.Sh. Arynova, Z.O. Onerbayeva, as well as international scholars such as N. Kavak, S. Gencer, H. Akkus.

The development of students' professionally significant skills through the use of information and computer technologies in chemistry education has been comprehensively studied by both domestic and international scientists, including A.R. Nurakhmetova, N.K. Akhmetov, A.E. Sagimbaeva, D.K. Berdy, S.A. Medetbayeva, G.M. Madybekova, N.T. Shertaeva, P.A. Abdurazova, as well as B.K. Hensiek, W.S. DeKorver, J. Harwood, K. Fish, etc.

A future chemistry teacher must master modern technologies during professional training at the university. Such training requires the selection of effective forms and methods for organizing the educational process using digital technologies, the development of students' skills in independently searching,

mastering and processing information, and the design of a methodological training system aimed at fostering these skills. Moreover, it has become a requirement of the time for future teachers to be able to develop and apply interactive teaching tools, electronic educational resources, computerized assessment and testing instruments, which enhance the quality of the educational process and ensure objective assessment of student knowledge.

In this regard, it is necessary to expand the opportunities for the use of digital technologies in higher education institutions as the basis for the development of professional competence among future teachers.

An analysis of the scientific literature has shown that the development of professional competence of future chemistry teachers and the integration of digital technologies within the higher education system have not yet been studied comprehensively. Under the current conditions of higher education, there is a need to clarify the content and essence of this process, to identify the features of its organization within the framework of professional training of future chemistry teachers, and to integrate digital technologies into the educational process.

Despite the fact that modern educational strategies, methods, and organizational forms are aimed at using digital technologies, the possibilities of using their didactic potential in the practice of teaching chemistry in higher education institutions have not been sufficiently identified, and the methodological support for the systematic use of digital technologies in the process of professional training of future chemistry teachers remains underdeveloped.

In this regard, the following **contradictions** have been identified: between the need of pedagogical higher education institutions to train future chemistry teachers with a high level of professional competence and the insufficient development of effective ways for implementing this process; and between the availability of digital technologies that have potential to foster the professional competence of future chemistry teachers and the lack of clearly revealed pedagogical conditions ensuring their effective use.

The search for ways to resolve these contradictions led to the identification of the research problem and provided the rationale for selecting the dissertation topic entitled **“Development of professional competence of future chemistry teachers based on digital technologies”**.

The purpose of the study is to theoretically and methodologically substantiate the process of developing professional competence of future chemistry teachers based on digital technologies, develop a methodology, and to verify its effectiveness through experimental research.

Object of the study the process of professional training of future chemistry teachers at a higher pedagogical educational institution.

Subject of the study methodology for developing professional competence of future chemistry teachers through digital technologies.

Scientific hypothesis of the study is that if the theoretical and methodological foundations of the development of professional competence of future chemistry teachers through the use of digital technologies are identified, along with the pedagogical conditions are determined, a structural-content model of this process and an accompanying methodology are developed and implemented, then the level of professional competence of future chemistry teachers will increase, since it is expected that students' stable professional motivation to use digital technologies will be developed, their subject-specific, psychological, pedagogical and digital knowledge will be deepened, their skills in using digital educational resources, platforms and virtual laboratories in professionally oriented educational activities will be enhanced, and their readiness to organize and manage the educational process in a digital educational environment will be strengthened.

Objectives of the study:

1. To identify the theoretical and methodological foundations of the development of professional competence of future chemistry teachers based on digital technologies;
2. To reveal the pedagogical conditions for the development of professional competence of future chemistry teachers based on digital technologies;
3. To develop a structural-content model for the development of professional competencies of future chemistry teachers based on digital technologies;
4. To develop a methodology for the development of professional competencies of future chemistry teachers based on digital technologies and experimentally verify its effectiveness.

Research methods: analysis of philosophical, psychological, and pedagogical literature related to the research topic; analysis and comparison of scientific sources addressing the research problem; content analysis, study and systematization of domestic and international pedagogical experience in the use of digital technologies in the educational process; modeling, conducting pedagogical experiments, diagnostics, surveys, statistical and mathematical processing and interpretation of the obtained results.

Scientific novelty of the study:

1. The theoretical and methodological foundations of the development of professional competence of future chemistry teachers based on digital technologies have been identified;
2. Pedagogical conditions for the development of professional competence of future chemistry teachers based on digital technologies have been revealed;
3. A structural-content model of the development of professional competence of future chemistry teachers based on digital technologies has been developed. Based on the model, an integrative digital micro-flipped method has been proposed for the first time.

4. A methodology for developing the professional competence of future chemistry teachers through digital technologies has been developed, and its effectiveness has been experimentally verified.

Practical significance of the study:

- For the first time in Kazakhstani pedagogical practice, an interactive educational and methodological complex for the course "Analytical Chemistry", supplemented with elements of digital technology, has been developed;

- A digital educational platform, CHEMED.KZ, aimed at developing the professional competence of future chemistry teachers based on digital technologies, has been developed for the first time;

- A computerized educational game, "Find the Ion", has been implemented in the professional training of future chemistry teachers;

- Two author's certificates have been obtained: the textbook "Analytical Chemistry", designed to develop students' professional competence based on digital technologies (22.01.2024., No. 42748); CHEMED.KZ, developed to implement the integrative digital micro-flipped method (17.11.2025., No. 64279);

- The use of the developed textbook and the CHEMED.KZ digital educational platform in higher and specialized pedagogical educational institutions contributes to improving the quality of future chemistry teachers.

Key provisions submitted for defense:

- "Professional competence of a future chemistry teacher" is defined as an integrated system of subject-specific, methodological, laboratory, research, communicative and digital skills that ensure the effective use of modern digital technologies, virtual experiments, and online platform capabilities in chemistry teaching. In the framework of this study, the structure of professional competence of a future chemistry teacher was defined as a set of motivational, cognitive, activity-based and organizational components. Within this study, digital technologies are understood as a system of software, multimedia, and interactive tools used to present educational content, organize learning activities, and develop professional competence of future chemistry teachers. The methodological foundations for developing professional competence of future chemistry teachers based on digital technologies include system, learner-centered, competency-based, and technological approaches.

- The pedagogical conditions for developing professional competence of future chemistry teachers based on digital technologies have been revealed, including: psychological and pedagogical conditions (professionally significant qualities of future chemistry teachers, students' goals and motivation, and content of education); organizational conditions (material and technical support of the educational process, and a rational combination of in-class and out-of-class learning activities); didactic conditions (adherence to didactic principles and selection of teaching forms and methods in accordance with the stated objectives).

- A structural-content model for developing professional competence of future chemistry teachers based on digital technologies has been developed, consisting of target, content-organizational, methodological and outcome components. Within the framework of this model, an integrative digital micro-flipped method, integrating microlearning, flipped classroom and scenario-based virtual laboratory techniques in teaching chemistry, has been scientifically and methodologically substantiated and proposed for the first time. This method is adapted to the training of future chemistry teachers and is aimed at the comprehensive development of both professional and digital competencies.

- For the first time, the educational process of pedagogical universities has incorporated the textbook "Analytical Chemistry", enriched with interactive tasks integrating elements of digital technology, as well as the chemed.kz digital educational platform, which implements the author's method and provides video lectures, complex interactive tasks, virtual laboratories and automated assessment tools. The effectiveness of the integrative digital micro-flipped method and the resulting digital resources has been experimentally validated.

The validity and reliability of the research results are ensured by the theoretical and methodological substantiation of the research topic, the correspondence of the research content to the scientific framework, the use of methods appropriate to the research purpose and objectives, object and subject the coherence and compatibility of theoretical and empirical research methods, the experimental verification of the effectiveness of the proposed methodical system, the application of the mathematical and statistical methods for data analysis, the confirmation of the scientific hypotheses, and the implementation of the experimental results into the educational process of universities.

Publications based on the research results. A total number of 16 publications reflecting the main content of the dissertation have been published, including: 1 article in a scientific journal indexed in the Scopus international database, 4 articles in journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Republic of Kazakhstan, 2 publications in the proceedings of international scientific and practical conferences held abroad, 4 publications in the proceedings of international scientific and practical conferences held in the Republic of Kazakhstan, 1 article in other scientific journals, 2 author's copyright certificates, 1 textbook, and 1 digital educational platform (chemed.kz).

In international journals indexed in the Scopus database:

1. Developing the Professional Competence of Future Chemistry Teachers through Digital Technologies: A Case Study of Kazakhstan. International Journal of Information and Education Technology. – 2024. – Vol.14(8). – P. 1119-1126 (CiteScore – 2.8; 61 th percentile). https://www.ijiet.org/vol14/IJIET-V14N8-2140.pdf

In domestic journals recommended by the Committee for Quality Assurance in Science and Higher Education (CQASHE):

2. Digital technology as a factor in the development of professional competence of future chemistry teachers. Bulletin of the National Academy of Sciences of the Republic of Kazakhstan, “Pedagogy and Economics” series. – 2022. - №4. – B.106. https://journals.nauka-nanrk.kz/bulletinscience/article/view/4660

3. Importance of digital technology application in the development of professional competence of future chemistry teachers. Bulletin of Karaganda University, "Pedagogy" series – 2023. – Vol. 109. -№1 – P. 45-54. https://rep.ksu.kz//handle/data/15988

4. Some issues of development of professional competence of perspective chemistry teachers. Bulletin of Abay Kazakh National University of Applied Sciences, "Pedagogy Sciences" series – 2023. – Vol. 80. –№4. –P. 238-251. https://doi.org/10.51889/2959-5762.2023.80.4.023

5. Use of gamification in digitizing the chemistry teaching process. Bulletin of the National Academy of Sciences of the Republic of Kazakhstan, "Pedagogy and Economics" series – 2025. - №4. – P. 177–193. https://doi.org/10.32014/2025.2518-1467.995

In the proceedings of international scientific-practical conference held abroad:

6. Peculiarities of distance learning of chemistry based on digital technology. The Europe and the Turkic World: Science, Engineering and Technology»: Materials of the VII International Scientific-Practical Conference. In three volumes. Volume II – Mersin, Turkey: Regional Academy of Management. – 2022. – P. 226-233.

7. Effectiveness of using digital technologies in blended learning of chemistry. 8th International Istanbul contemporary scientific research Congress. – October 10-12. – 2025. – P. 498-506

In the proceedings of international scientific-practical conference held in the Republic of Kazakhstan:

8. Some issues of forming the competence of future teachers in the use of digital technologies and the formation of information culture. International scientific and practical conference "Independent Kazakhstan: Modern Educational Potential and Achievements" - Zhetysai, 2021. - P. 691.

9. Distance learning of chemistry for 8th grades using the edmodo system. International scientific and practical conference "The Phenomenon of Akhmet Baitursynuly and the Horizon of Modern Humanitarian Science" - Shymkent, 2022. - P. 537.

10. The effectiveness of using digital educational resources in chemistry lessons. International scientific and practical online conference "Trends in the Development of Modern Science and Education" - 2022. - P. 85-88.

11. Teaching chemistry based on digital technologies. International scientific and practical conference "Independence is the Eternal Foundation of the Nation" - Shymkent, 2021. - P. 244.

In other scientific journals:

12. The importance of organizing independent work in chemistry lesson. Eurasian Journal of Researches in Social and Economics – 2023. – P.130-142.

Teaching and learning resources:

13. Analytical chemistry (part 1). Textbook. – Shymkent: O. Zhanibekov South Kazakhstan Pedagogical University, 2024. – 220 p.

14. Chemed.kz digital educational platform

Copyright certificates:

15. Analytical chemistry (part 1). Copyright certificate issued by the RSE "National Institute of Intellectual Property" of the Ministry of Justice of the Republic of Kazakhstan. 22.01.2024. - No. 42748.

16. Chemed.kz digital educational platform. Copyright certificate issued by the RSE "National Institute of Intellectual Property" of the Ministry of Justice of the Republic of Kazakhstan. 17.11.2025. - No. 64279.

Structure of the dissertation. The dissertation consists of an introduction, three chapters, a conclusion, a list of references, and appendices, in full accordance with the approved research plan.

The content of the dissertation and its implementation in the educational process were based on the model of development of professional competence of future chemistry teachers based on digital technologies, developed within the framework of this study. The practical testing of the proposed model was carried out using the chemed.kz digital educational platform with the aim of digitizing the educational process and improve the quality of students' professional training.