

ANNOTATION

dissertation work of Ussainova Gulzhamal Manatbekovna, on the topic "Instructional design in the system of professional training of future mathematics teachers in the conditions of digitalization of education" submitted for the degree of Doctor of Philosophy (PhD) in the educational program 8D01510 – Mathematics Teacher Training

Relevance of the research topic.

The relevance of the research is determined by the fundamental principles of state policy in the field of education, as defined in the Law of the Republic of Kazakhstan dated July 27, 2007 No. 319 “On Education”.

This law identifies key priorities such as improving the quality of education, developing education based on innovative and digital technologies, and training competitive specialists.

In particular, it emphasizes that the education system must focus on improving the learning process, implementing modern educational technologies, and developing students’ professional competencies.

These requirements актуализируют the need to develop a scientifically grounded system for the professional training of future mathematics teachers in the context of digital education, including the effective application of pedagogical design.

From this perspective, adapting pedagogical design to digital education, its theoretical substantiation, and practical validation align with national educational strategies and current educational demands.

The Concept for the Development of Preschool, Secondary, Technical and Vocational Education in the Republic of Kazakhstan for 2023–2029 identifies systematic professional development of teachers as a key condition for ensuring the quality of educational services.

In this concept, teacher training and continuous professional development are considered strategic priorities.

The Strategic Development Plan of Kazakhstan until 2025 defines high-quality education and skills development aligned with labor market demands as essential conditions for human capital development. The document emphasizes that education should not be limited to knowledge acquisition but should focus on developing professional, functional, and digital skills.

President of the Republic of Kazakhstan Kassym – Jomart Kemeluly Tokayev, in his Address to the People of Kazakhstan titled “A Just Kazakhstan: Law and Order, Economic Growth, Public Optimism” delivered in September 2024, emphasized the need to enhance the quality of human capital as one of the strategic development priorities of the country, including improving the effectiveness of the education system and training personnel in line with modern requirements. The Address highlights that the education sector is one of the key factors ensuring sustainable socio-economic development and shaping the future of society.

The President’s Address also stresses the importance of forming a new quality of society through high-quality education, the development of essential skills, the

enhancement of teachers' professional competence, and the systematic integration of innovative technologies, including digital tools, into the educational process. These requirements impose new content-related and methodological tasks on the system of teacher education, emphasizing the formation of teachers not only as transmitters of knowledge but also as professionals capable of scientifically designing the educational process.

These requirements place new content-related and methodological challenges on the system of future teacher education in the context of digital transformation. This is due to the fact that the quality of human capital is directly linked to the level of teachers' professional training, their ability to scientifically design the educational process, and their effective use of modern pedagogical technologies. In this regard, organizing the professional training of future mathematics teachers in a digital education environment based on instructional design is considered an important mechanism for ensuring high-quality education and developing necessary competencies.

The readiness of future mathematics teachers for independent educational activity within the paradigm of lifelong learning ensures their ability to quickly adapt to socio-economic changes in the context of digital transformation, to rapidly master new educational technologies and digital pedagogical tools, and to effectively organize the learning process based on instructional design.

The Strategic Development Plan of the Republic of Kazakhstan until 2025 states that the new model of economic growth is based on five principles, one of which involves a fundamental transformation of the education system, shifting away from traditional methods based on memorization and reproduction of knowledge. This principle prioritizes the development of creative and cognitive skills at all levels of education, the widespread implementation of technologies, and the achievement of universal digitalization. These requirements necessitate the revision of the content of professional training for future mathematics teachers in the context of digital transformation, emphasizing the scientific design of the educational process, as well as the systematic application of new pedagogical approaches and digital technologies. In this regard, the importance of considering instructional design as a key methodological foundation in the professional training system of future mathematics teachers is increasing.

Thus, the requirements for high-quality education, human capital development, the formation of creative and cognitive skills, and universal digitalization, as outlined in state strategic documents, impose new content-related and methodological tasks on the system of training future mathematics teachers. In this context, the preparation of future mathematics teachers with well-developed logical thinking and digital competencies based on instructional design becomes one of the urgent issues of the modern education system.

Issues of modernizing the education system under conditions of digital transformation have been widely studied in recent years. Particular attention is paid to the use of digital technologies, the development of professional competencies, and the scientific design of the learning process.

The problem of instructional design is addressed within several scientific domains. The professional training of future teachers in the context of digital education is one of the key areas of modern pedagogical science and is based on studies in instructional design, digital and online learning, the formation of professional digital competencies, and the application of technologies in mathematics education.

Foreign scholars such as Charles M. Reigeluth, Robert M. Branch, and M. David Merrill have contributed significantly to the theory of instructional design. The Community of Inquiry model (Garrison, Anderson, Archer) explains online learning interaction.

The TPACK framework (Mishra, Koehler) highlights the integration of technological, pedagogical, and content knowledge. Digital mathematics education has been studied by Drijvers, Borba, and Artigue. A.A. Verbitsky proposes the concept of contextual learning aimed at bringing the process of professional training closer to the conditions of the future professional activity of a specialist. In his research, the design of the educational process is considered a key condition ensuring students' adaptation to professional activity, which conceptually aligns with the principles of instructional design.

In addition, the application of project-based and systemic approaches in professional training is addressed in the works of N.F. Talyzina, V.A. Slastenin, and I.Ya. Lerner, where the necessity of organizing teacher training content based on competency-based and outcome-oriented approaches is substantiated.

Studies by scholars from CIS countries also address the improvement of professional training of future teachers, the design of the educational process, and the pedagogically grounded use of digital technologies. In this context, the works of A.Kh. Kasymzhanov, R.M. Koyanbaev, and A.K. Kurbanov examine issues related to the systematic organization of the educational process, the enhancement of teachers' professional training, and the modernization of educational content. In general, the works of Russian and CIS scholars consider pedagogical technologies and design as key mechanisms for improving the effectiveness of the professional training system. However, in most of these studies, the issue of instructional design is analyzed from general pedagogical or technological perspectives and is not specifically considered as a core structural component of the professional training system of future mathematics teachers in the context of digital education. This circumstance determines the scientific novelty and relevance of the present study.

The conducted scientific analysis has shown that in the works of Kazakhstani scholars, issues of instructional design, digital learning, and the use of technologies in mathematics education have been sufficiently studied in certain aspects. However, the problem of substantiating instructional design as a holistic systemic phenomenon in the professional training system of future mathematics teachers in the context of digital education, as well as experimentally proving its effectiveness, has not been sufficiently developed. This determines the relevance and scientific novelty of the study.

At the same time, the analysis revealed that instructional design issues are most often considered within the framework of general pedagogy, e-course design,

or individual disciplines. However, the problem of substantiating instructional design as a holistic authorial system in the professional training of future mathematics teachers, defining its structural-content components, and experimentally confirming its effectiveness remains insufficiently studied. This gap determines the scientific novelty and relevance of the study.

During the theoretical and practical analysis of the research problem, the following scientific contradictions were identified:

- between the increasing professional requirements for future mathematics teachers in the context of digital education and the lack of systematic application of instructional design in their training;
- between the need for the widespread use of digital technologies and educational resources and the absence of a holistic instructional design system aimed at designing the educational process in a digital environment;
- between the expanding educational potential of digital and artificial intelligence technologies and the lack of clearly defined mechanisms for their effective implementation in the professional training system of future mathematics teachers through instructional design.

These contradictions determine the necessity of developing a comprehensive, scientifically grounded, and practically implementable system of professional training for future mathematics teachers based on instructional design in the context of digital education and define the research problem.

The analysis of the reviewed scientific works and dissertation studies has shown that there remain unresolved theoretical, methodological, and practical issues in the professional training system of future mathematics teachers in the context of digital education. In particular, the issue of designing a comprehensive, systematic, and outcome-oriented training model integrating instructional design with digital and artificial intelligence tools has not been sufficiently studied. These contradictions and gaps, as well as modern requirements for the education system, determine the relevance of the research and served as the basis for choosing the dissertation topic: “Instructional Design in the Professional Training System of Future Mathematics Teachers in the Context of Digital Education”.

The purpose of the dissertation research work: To provide a scientific and theoretical substantiation of pedagogical design in the system of professional training of future mathematics teachers in the context of digital education, to define its structural and content components, and to experimentally prove the effectiveness of the author’s pedagogical design-based training system.

Research object: The process of professional training of future mathematics teachers in the system of higher pedagogical education.

Subject of the Research

Pedagogical design in the system of professional training of future mathematics teachers in the context of digital education, including its theoretical and methodological substantiation, design, implementation, structure, content, organizational mechanisms, and assessment tools.

Research forecast:

If a pedagogical design model adapted to the conditions of digital education is introduced into the professional training system of future mathematics teachers, then the educational process will be organized on a scientific basis, and its effectiveness will increase; students' digital and methodological competencies will be systematically developed; the quality of mastering mathematical concepts will improve; learning motivation and cognitive activity will increase; and the accessibility and flexibility of the learning process will be ensured.

Research hypothesis: The stated aim, object, subject, and hypothesis of the research determine the necessity of solving the following main research tasks:

1. To analyze the theoretical and methodological foundations of the professional training of future mathematics teachers in the context of digital education and to clarify the essence of the concept of pedagogical design;
2. To identify the modern requirements for the professional training of future mathematics teachers (digital, pedagogical, subject-specific, and methodological competencies);
3. To develop a theoretical and methodological model of pedagogical design aimed at improving the professional training of future mathematics teachers in the context of digital education (defining its structural-content components, stages, and implementation conditions);
4. To test and prove the effectiveness of the proposed pedagogical design model through experimental research.

Scientific novelty of the research:

- the theoretical and methodological foundations of using instructional design in the professional training system of future mathematics teachers in the context of digital education were clarified;
- modern requirements for the professional training of future mathematics teachers were systematized, and the interrelation of subject-specific, pedagogical, digital, and instructional design competencies within their structure was substantiated;
- a theoretical and methodological model of instructional design aimed at improving the professional training of future mathematics teachers in the context of digital education was developed, and its structural components (target, content, technological, organizational, and result-evaluation components) were defined;
- an authorial methodology focused on the use of digital educational technologies based on instructional design was proposed, and its effectiveness was proven through experimental research;
- scientifically grounded approaches to the integration of instructional design with digital and artificial intelligence tools were proposed.

Theoretical significance of the research:

- the essence, structure, and functions of the concept of instructional design were deepened and theoretically specified in the context of digital education;
- a scientific concept of applying instructional design in the professional training system of future mathematics teachers was developed;
- the system of competencies within the structure of professional training (subject-specific, pedagogical, digital, and design competencies) was substantiated in an integrated manner;

- the developed theoretical and methodological model was presented as a systematic scientific structure contributing to the development of pedagogical education theory;
- the theoretical foundations of designing the learning process in the context of digital education were further developed.

Practical significance of the research:

- a theoretical and methodological model based on instructional design was developed for implementation in the training process of future mathematics teachers;
- an authorial methodology aimed at the effective use of digital educational technologies was proposed, which can be applied in the educational process of higher education institutions;
- the developed instructional and methodological recommendations and materials can be used in teaching pedagogical disciplines, especially in the courses “Methods of Teaching Mathematics” and “Elementary Mathematics”;
- recommendations on the use of digital platforms and artificial intelligence tools contribute to the development of students’ professional competencies;
- the research results can be used in professional development courses, teacher retraining systems, and in the updating of educational programs.

Main propositions submitted for defense (substantiated scientific hypotheses and other conclusions representing new knowledge):

1. The scientific and pedagogical role of instructional design in the professional training system of future mathematics teachers in the context of digital education was substantiated. Accordingly, instructional design was defined as an effective theoretical and methodological mechanism for organizing professional training in a goal-oriented, systematic, and result-oriented manner.
2. An authorial theoretical and methodological model of instructional design aimed at improving the professional training of future mathematics teachers was developed. The model is based on the integration of digital and artificial intelligence tools, and its structural-content components and implementation logic were defined.
3. Methodological mechanisms for implementing instructional design that ensure the systematic integration of digital and artificial intelligence tools into the professional training process of future mathematics teachers were substantiated. These mechanisms are aimed at developing professional-methodological and digital competencies.
4. The effectiveness of the proposed instructional design model was proven through experimental research. The results demonstrated an increase in the professional training level of future mathematics teachers in both quantitative and qualitative indicators.

Reliability and validity of the research results

The reliability and validity of the scientific results are ensured by the organization of the research in accordance with modern scientific and methodological requirements, as well as by the use of a complex of interrelated and complementary research methods that correspond to the objectives and tasks of the study and the specific features of the investigated pedagogical phenomenon. During the research,

the use of modeling methods and the implementation of a pedagogical experiment, as well as the reproducibility of the obtained results and the representativeness of experimental data, were confirmed through quantitative and qualitative analysis. In addition, the application of mathematical statistics methods in processing and summarizing the experimental results made it possible to increase the accuracy of the scientific conclusions.

Propositions submitted for defense:

1. The scientific and pedagogical role of instructional design in the professional training system of future mathematics teachers in the context of digital education was substantiated, according to which instructional design was defined as an effective theoretical and methodological mechanism for the goal-oriented, systematic, and result-oriented organization of professional training.
2. An authorial theoretical and methodological model of instructional design aimed at improving the professional training of future mathematics teachers was developed. The model is based on the integration of digital and artificial intelligence tools, and its structural-content components and implementation logic were defined.
3. Methodological mechanisms for implementing instructional design that ensure the systematic integration of digital and artificial intelligence tools into the professional training process of future mathematics teachers were substantiated. These mechanisms are aimed at developing professional-methodological and digital competencies.
4. The effectiveness of the proposed instructional design model was confirmed through experimental research, and the results demonstrated an increase in the professional training level of future mathematics teachers in both quantitative and qualitative indicators.

Main stages of the research:

In accordance with the aim and objectives of the research, the experimental work was carried out under normal educational conditions during 2022–2025 and consisted of three stages.

The first stage – ascertaining stage (2022–2023):

At this stage, the theoretical and methodological foundations of the research problem were identified, and pedagogical, psychological, methodological literature, as well as regulatory and legal documents were analyzed. The initial level of professional training of future mathematics teachers was determined, and the current state of applying instructional design in the context of digital education was studied. In addition, the object and subject of the research were clarified, the aim, tasks, and scientific hypothesis were defined, and diagnostic tools and evaluation criteria were developed.

The second stage – formative stage (2023–2024):

At this stage, a theoretical and methodological model of instructional design aimed at improving the professional training of future mathematics teachers was developed and implemented in the educational process. Methodological mechanisms ensuring the integration of digital and artificial intelligence tools into the professional training

process were implemented. Within the framework of the formative experiment, lectures, practical and laboratory classes were organized in accordance with instructional design principles, and learning tasks aimed at developing students' professional-methodological, digital, and pedagogical design competencies were applied.

The third stage – control and concluding stage (2025):

At this stage, the results of the pedagogical experiment were summarized, and initial and final indicators were comparatively analyzed. The obtained experimental data were processed in both quantitative and qualitative terms, and the effectiveness of the proposed instructional design model was confirmed using mathematical statistics methods. The research results were systematized, and conclusions and scientific-methodological recommendations were developed.

Approval and implementation of the research results:

The scientific results of the dissertation research were approved by the academic community and implemented in educational practice.

During the course of the dissertation work, a total of 14 scientific publications were published.

Based on the main content of the dissertation, 14 scientific works were published:

1. Scientific articles published in journals indexed in the Scopus database – 1 (percentile – 74, Quartile – Q2);
2. Scientific articles published in journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan – 4;
3. Scientific articles published in the proceedings of international scientific and practical conferences – 8;
4. Articles published in other scientific journals and publications – 2;
5. Author's certificate – 1.