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

The relevance of the research is determined by the fact that improving the quality of education is a strategic priority of state policy amid digital transformation. The Law of the Republic of Kazakhstan “On Education,” the Education Development Concept for 2023–2029, and the Strategic Development Plan until 2025 emphasize improving education quality, introducing digital technologies, and developing professional and creative skills.

In Presidential Addresses, special attention is given to enhancing human capital, improving teachers’ professional competencies, and systematically integrating digital technologies into education. This requires the preparation of future teachers, including mathematics teachers, based on scientifically grounded instructional design.

In this regard, training future mathematics teachers in a digital education environment based on pedagogical design is highly relevant, as it contributes to the development of their professional and digital competencies as well as their ability to design the learning process scientifically. Moreover, contemporary pedagogical research increasingly focuses on digital technologies and learning design, which further strengthens the relevance of the topic.

The issue of instructional design is addressed across 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 draws on studies of instructional design, digital and online learning, the formation of professional digital competencies, and the application of technologies in mathematics education.

The issues of systematic instructional design have been widely examined in the works of foreign scholars. In particular, Charles M. Reigeluth (1999) described pedagogical design as theoretical and prescriptive knowledge aimed at improving the quality of instruction and substantiated the importance of designing educational content, methods, and outcomes within an integrated system. The ADDIE (Analyze, Design, Development, Implementation, Evaluation) model proposed by Robert M. Branch enables the organization of the instructional process through the stages of analysis, design, development, implementation, and evaluation (2009). M. David Merrill (2002), through his First Principles of Instruction, proposed pedagogical design solutions that ensure learners’ active cognitive engagement. These studies highlight the role of pedagogical design in the scientific organization of the instructional process within a digital environment. Issues of pedagogical interaction in digital and online learning environments were examined in the Community of Inquiry model developed by D. Randy Garrison, Terry Anderson, and Walter

Archer, which substantiates the teaching, cognitive, and social components of effective online learning (2000). In addition, D. Keegan proposed a theory explaining the relationship between structure, dialogue, and learner autonomy in distance education.

The integration of digital technologies into subject teaching in the professional preparation of future teachers is grounded in the TPACK (Technological Pedagogical Content Knowledge) framework proposed by Punya Mishra and Matthew J. Koehler. This model considers the integration of technological, pedagogical, and content knowledge as an essential condition for the professional competence of future teachers.

The application of digital technologies in mathematics education has been explored in the works of Paul Drijvers, Marcelo C. Borba, and Michèle Artigue, where the didactic potential of digital tools for visualizing mathematical content, modeling, and interactive learning was identified (2022). These studies provide a scientific basis for the effective organization of mathematics instruction in digital environments while taking into account the specific features of mathematics as a subject.

At the same time, the issues of pedagogical technology and instructional design were considered in the studies of Russian scholars such as V. P. Bespalko, E. S. Polat, and A. A. Verbitsky, who emphasized the importance of designing professional training as an outcome-oriented system.

In particular, V. P. Bespalko considered pedagogical technology as an integrated system based on the interrelation of learning objectives, content, methods, and outcomes, and scientifically substantiated the effectiveness of preliminary instructional design of the educational process. In his works, the measurability and guaranteed achievement of learning outcomes are described as one of the key principles of pedagogical design.

The issues of applying pedagogical technologies in digital and distance learning environments were comprehensively examined in the works of E. S. Polat. The scholar emphasized the necessity of pedagogically appropriate design of educational content, teaching methods, and information and communication tools when implementing distance and blended learning technologies into the educational process. These concepts serve as an important theoretical foundation for improving the system of training future teachers in the context of digital education.

A. A. Verbitsky proposed the concept of contextual learning aimed at bringing the process of professional training closer to the context of future professional activity. In his studies, the design of the educational process is considered a key condition for ensuring students' adaptation to professional activity, which conceptually aligns with the ideas of pedagogical design.

In addition, the application of project-based and systemic approaches in professional training was examined in the works of N. F. Talyzina, V. A. Slastenin, and I. Ya. Lerner, who substantiated the necessity of organizing teacher education content in a competency-based and outcome-oriented manner.

The studies of scholars from the CIS countries also addressed the issues of improving future teachers' professional training, designing educational processes,

and applying digital technologies in pedagogy. In this regard, the works of A. Kh. Kassymzhanov, R. M. Koyanbayev, and A. K. Kurbanov examined the systematic organization of the educational process, the improvement of teachers' professional training, and the modernization of educational content.

In general, the works of domestic, Russian and CIS scholars consider pedagogical technology and instructional design as key mechanisms for improving the effectiveness of professional training systems. However, in most of these studies, pedagogical design has been analyzed mainly from general pedagogical or technological perspectives and has not been specifically considered as a core 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.

An analysis of scholarly works shows that the formation and development of instructional design competencies among future mathematics teachers have been studied from various perspectives. However, the systematic formation of instructional design competencies in the context of digital technologies has not been sufficiently investigated. In this regard, the following **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 system;
- between the need for the widespread use of digital technologies and educational resources in the training of future mathematics teachers and the absence of an integrated instructional design system aimed at designing the educational process in a digital environment.

These contradictions determine the need to develop an instructional-design-based training system for future mathematics teachers in the context of digital education and define the research problem. The conducted analysis revealed theoretical, methodological, and practical issues that have not yet been fully resolved in this field. In particular, insufficient attention has been paid to the holistic, systematic, and outcome-oriented design of a training system integrating instructional design with digital platforms. These gaps, along with the current requirements of the education system, determine the relevance of the research and served as the basis for selecting the dissertation topic.

The purpose of the research is to theoretically substantiate instructional design in the professional training system of future mathematics teachers and to methodologically determine the impact of digital educational technologies. The object of the research is the process of professional training of future mathematics teachers.

The subject of the research is the process of designing, implementing, and evaluating the effectiveness of instructional design in the professional training system of future mathematics teachers based on digital technologies.

The research hypothesis is that if instructional design in the professional training system of future mathematics teachers under conditions of digital education is theoretically substantiated, methodologically developed, and implemented in the

educational process, then the level of their professional training will increase, since the visualization capabilities of digital technologies contribute to the effective assimilation of mathematical content and improvement of education quality.

In accordance with the purpose of the research and the proposed hypothesis, the following **objectives** were identified:

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 "instructional design";
2. To determine 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 instructional design aimed at improving the professional training of future mathematics teachers in the context of digital education (to determine its structural-content components, stages, and implementation conditions);
4. To develop a methodology for improving the professional training of future mathematics teachers through digital educational technologies and to experimentally test and confirm the effectiveness of the proposed instructional design model.

Scientific novelty of the research:

1. The theoretical and methodological concept of applying instructional design in the system of professional training of future mathematics teachers in the context of digital education has been clarified;
2. Modern requirements for the professional training of future mathematics teachers have been systematized, and the interrelation of subject-specific, pedagogical, digital, and instructional design competencies within their structure has been substantiated;
3. A model for improving the professional training of future mathematics teachers through instructional design in the context of digital education has been developed;
4. A methodology for improving professional training based on instructional design through the use of digital educational technologies has been developed.

Theoretical significance of the research results:

The study revealed the absence of a unified scientific interpretation of the concept of instructional design in scholarly works, which made it possible to clarify its content. In particular, instructional design was defined as "the process of organizing instruction based on cognitive structures and directing learners toward active cognitive activity".

Furthermore, in the context of the digital transformation of future mathematics teacher training, instructional design is interpreted as the effective design of the educational process in accordance with learners' characteristics through the integration of mathematical content and digital tools within the unity of target, content, technological, and assessment components.

Accordingly, the theoretical foundations of instructional design were identified, and its structural model was proposed. The proposed model aims to organize the training of future mathematics teachers in accordance with the requirements of higher pedagogical education.

Practical significance of the research results:

The "Instructional design model aimed at improving the professional training of future mathematics teachers" proposed in the study can serve as a methodological basis for developing the professional-methodological and digital competencies of students enrolled in the educational programs "Mathematics" and "Mathematics and Informatics".

In the process of improving the professional training level of students in these educational programs, it is proposed to use the author's course "Instructional design of mathematics teaching in a digital environment" developed on the Stepik.org educational platform, taking into account the capabilities of digital platforms and programming languages.

This course has been implemented in the educational process and contributes to increasing students' readiness to teach mathematics in a digital environment.

Main propositions submitted for defense:

1. The theoretical and methodological provisions for the application of instructional design in the system of professional training of future mathematics teachers in the context of digital education were clarified, and its content and structure were defined, which may serve as a theoretical basis for improving the training system of future teachers.
2. Modern requirements for the professional training of future mathematics teachers were systematized, and the interrelation of subject-specific, pedagogical, digital, and instructional design competencies was substantiated, which can contribute to the comprehensive development of their professional training.
3. An instructional design model aimed at improving the professional training of future mathematics teachers in the context of digital education was developed, which may serve as a methodological basis for organizing the educational process.
4. A methodology for improving professional training through the use of digital educational technologies based on instructional design was developed, which can positively influence the enhancement of the training level of future mathematics teachers.

The reliability and validity of the research results are ensured through a comprehensive analysis of scientific and educational-methodological literature on the research problem; the application of a set of scientific methods corresponding to the aims and objectives of the study, as well as ensuring the interrelation between theoretical and experimental research; furthermore, through the use of statistical methods and mathematical data processing techniques in validating the experimental results.

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 classes were organized in accordance with instructional design principles, and learning tasks aimed at developing students' professional-methodological, digital, and instructional design competencies were applied.

The third stage – control and concluding stage (2024-2025):

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 main results of the research were presented and discussed at the scientific and methodological seminar of the "Physics and Mathematics" educational program of the Institute of Natural Sciences at Kyzylorda University named after Korkyt Ata. The research findings were also presented at a scientific seminar of the Faculty of Physics and Mathematics at Zhetysu University named after I. Zhansugurov. In addition, the results were reviewed and discussed during a scientific internship at the Faculty of Education of Hacettepe University in Ankara.

An elective course entitled "Instructional design of the digital educational environment" was introduced for second-year students enrolled in the "Mathematics Teacher Training" educational programs (6B01501 – Mathematics, 6B01502 – Mathematics and Informatics) at the Institute of Natural Sciences of Korkyt Ata Kyzylorda University named after Korkyt Ata.

In addition, an author-developed online learning platform for students entitled "Instructional design of mathematics teaching in a digital environment" (https://stepik.org/272365) was created and implemented in the educational process.

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

Based on the main content of the dissertation, 16 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 – 9;
4. Articles published in other scientific journals and publications – 1;
5. Author's certificate – 1.

Structure of the dissertation. The dissertation consists of normative references, definitions, abbreviations, an introduction, two chapters, a conclusion, a list of references, and appendices.

The introduction substantiates the relevance of the research topic and defines the aim and objectives, object and subject of the study, research hypothesis, theoretical and methodological foundations, scientific novelty, theoretical and practical significance, and the provisions submitted for defense, as well as presenting the approval and implementation of the research results.

The first chapter – "Theoretical and methodological foundations of instructional design in the professional training of future mathematics teachers" – is devoted to the analysis of pedagogical and psychological aspects of training future mathematics teachers. This chapter defines the role of instructional design theories in professional training, examines the features of its implementation in the context of digital education, pedagogical conditions, and indicators for assessing the level of professional training of future teachers. Instructional

The second chapter – "The model of instructional design and its implementation in the context of digital education for improving the professional training of future mathematics teachers" – represents the applied part of the research. This chapter presents a developed model for improving the professional training of future mathematics teachers based on instructional design and describes the methodology for its implementation. It also considers the use of digital educational resources and technologies, as well as provides quantitative and qualitative analysis of the results of the pedagogical experiment.

The conclusion summarizes the research findings and presents the main conclusions and recommendations.

The list of references includes the scientific works used in the study, while the appendices contain test assignments, the certificate of the author's course, and acts of implementation of the research results into the educational process of Kyzylorda University named after Korkyt Ata and Kyzylorda «Bolashak» University.