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KARATAYEVA MALIKA SAKENQYZY

Title: Methodological foundations of training future computer science teachers to implement STEM education

ABSTRACT

of a dissertation for the degree of Doctor of Philosophy (PhD)

Shymkent, 2025

The dissertation was completed at the Department «Computer Science» of the M.Auezov South Kazakhstan University.

National Scientific adviser: Berkimbaev Kamalbek Mayrbekovich, Doctor of Pedagogical Sciences, Professor, Akhmet Yassawi International Kazakh-Turkish University, Turkestan, Kazakhstan.

Foreign Scientific consultant: Grinshkun Vadim, Doctor of Pedagogical Sciences, Professor, Moscow City Pedagogical University, Russian Federation.

Official reviewers: Serik Meruert-Doctor of Pedagogical Sciences, Professor of the Department «Computer Science» at the Eurasian National University
Bostanov Bektas-Candidate of Pedagogical Sciences, Associate Professor of the Department «Computer Science» of Kazakh National Pedagogical University named after Abai

The defense will take place on **March 14, 2025 year at 10.00 a.m.** at the Dissertation Council "Computer Science " at the M. Auezov South Kazakhstan University at the address: 160012, Shymkent, Tauke Khan Avenue, 5, Main Building, auditorium 342.

Scientific Secretary of the Dissertation Council, Candidate of Technical Sciences, Associate Professor, Kemelbekova Zh. S.

ANNOTATION
of the doctor of philosophy (PhD) dissertation in the field of
specialty 8D01503- "Computer Science"
Karatayeva Malika Sakenqyzy

Research topic: Methodological foundations of training future computer science teachers to implement STEM education

The purpose of the study: Theoretically substantiate the training of future computer science teachers to implement STEM education and to prove the effectiveness of the proposed methodology in practical and experimental work.

Research objectives:

1. To identify the theoretical foundations of training future computer science teachers to implement STEM education;
2. To propose a model of training future computer science teachers to implement STEM education;
3. To determine the didactic conditions for training future computer science teachers to implement STEM education;
4. To propose methods of training future computer science teachers to implement STEM education and to verify their effectiveness experimentally.

Research methods. Theoretical (analysis, summary, comparison, synthesis, grouping of philosophical, psychological, pedagogical and scientific methodological literature); empirical (monitoring of the learning process, tests, surveys, interviews, practical experimental work) and statistical (mathematical and statistical processing of the reliability of research results) methods are used in accordance with the research topic.

Basic provisions (proven scientific hypotheses and other conclusions that are found as a new knowledge).

Theoretical foundations of training future computer science teachers to implement STEM education;

Model of training future computer science teachers to implement STEM education;

Didactic conditions for training future computer science teachers to implement STEM education.

Modern teaching methodology for training future computer science teachers to implement STEM education and the results of a pedagogical experiment proving its effectiveness.

Description of the main results of the study

During the theoretical substantiation of the research problem, the main concepts of the dissertation were clarified. Training future computer science teachers is the result of mastering general and professional competencies in the moral-

psychological, methodological, theoretical, practical and methodological terms in accordance with the development of science and technology, technology in the environment of information education.

The definition of "STEM education is a purposeful organized process of helping an individual acquire and develop skills (cognitive and creative) through the continuity of science, technology, engineering and mathematics disciplines";

STEM education as a modern educational phenomenon that forms students' skills in solving non-standard life situations, based on interdisciplinary connections and their practical application - in the implementation of the training of future computer science teachers for STEM education, mainly general philosophical, technological, methodological approaches of a special level were taken as a basis: competency, andragogic, systemic, individual action, resource and interdisciplinary, transdisciplinary, technological approaches.

The principle of unity of theory and practice was determined as a rule; the principle of a specific historical and creative approach to the problem under study; the principle of objectivity; the principle of studying the comprehensiveness of the process and phenomenon and the principles of systematicity were identified.

A model for training future computer science teachers for the implementation of STEM education was proposed. The model was developed to optimize the process of preparing future computer science teachers for STEM education in higher education institutions. The model consists of the following structural components: goal-oriented, conceptual, content-oriented, process-oriented, and assessment-effectiveness, reflecting the learning process. This model is the basis for developing the readiness of future computer science teachers for the STEM educational process.

STEM education in computer science connects classroom learning with real-world applications. Students explore how computer science is used in various fields, such as healthcare, finance, transportation, and entertainment. The essence of STEM education is to provide students with a holistic and interdisciplinary education that prepares them for the demands of a technology-based world. It is aimed at developing critical thinking, problem-solving skills, creativity, and innovation, and is also based on the principles and practices of computer science

The training of future computer science teachers in STEM education is carried out in three main directions:

- personalizing STEM education.
- STEM education and project approach,
- STEM education requires organizing the educational process in a blended learning format.

The didactic conditions for training future computer science teachers for STEM education were determined:

- The creation of the content of "STEM" education for future computer science teachers, the provision of didactic educational materials for training future computer science teachers for STEM education;

- To cover the process of preparing future computer science teachers for the implementation of STEM education with Didactic Educational Materials;

- Providing a resource base for the process of training future computer science teachers for the implementation of STEM education;

- The unity of the reproductive and productive nature of the cognitive activity of future computer science teachers in the implementation of STEM education.

Modern teaching methods for training future computer science teachers for the implementation of STEM education were proposed. The technology for implementing STEM education was analyzed, and the effectiveness of using project learning, coding tasks and competitions, cooperative learning, integrated robotics training, self-study, design methods, gamification, flipped learning ("flipped learning") technologies in the training of future computer science teachers was clarified and the methodology was disclosed.

Within the framework of the subject "STEM-education", "Fundamentals of Robotics Programming", a methodological system for the use of the above methods was developed. In the training of future computer science teachers, the effectiveness of the methodology for training future computer science teachers to implement STEM-education through the use of "STEM education" and "Fundamentals of Robotics Programming", "Educational Robotics" and professional practice, teaching students to creative design in scientific research and independent work, was proven during the pedagogical experiment.

The novelty and significance of the results obtained.

1. The theoretical significance of the study is based on the general philosophical, technological, methodological approaches of a special level in the implementation of STEM education for future computer science teachers.

2. A model for training future computer science teachers to implement STEM education is proposed,

3. Didactic conditions for training future computer science teachers to implement STEM education are determined.

4. The disciplines "STEM Education", "Fundamentals of Robotics Programming", "Educational Robotics" and the massive open online course "STEM Education" were introduced, and the effectiveness of the methodology for preparing future computer science teachers to implement STEM education was proven during a pedagogical experiment.

Compliance with the development directions of science or state programs.

The research topic is characterized by the main directions specified in the Law of the Republic of Kazakhstan "On Education" and the Concept of the Development of Higher Education and Science of the Republic of Kazakhstan for 2023-2029, as well as in the State General Obligatory Standard of Higher and Postgraduate Education.

The contribution of the doctoral student to the preparation of each publication. The main conclusions of the research work, the content of theoretical and practical scientific results were published at international scientific and practical conferences, in scientific publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Education and Science of the Republic of Kazakhstan, in scientific journals included in the Scopus database:

1. Development of a Framework for Predicting Students' Academic Performance in STEM Education using Machine Learning Methods. International Journal of Advanced Computer Science and Applications. – 2024. – Vol. 15, Iss. 1.– P.38-46.(CiteScore-2.1; 44th percentile) DOI: 10.14569/IJACSA.2024.0150105 (Abdrakhmanov, R., Zhaxanova, A., Berkimbayev, K., Tuimebayev, A. doctoral student share – 72%).

2. Didactic conditions for training future computer science teachers based on the “STEM” educational program. // Bulletin of the Kazakh University of International Relations and World Languages named after Abylaikhan, “Pedagogical Sciences” series, Almaty. – “Polilingva Publishing House” 2023.- P.86-97 <https://doi.org/10.48371/PEDS.2023.68.1.006> (V.V. Grinshkun, G.S. Karataev - doctoral share – 90%).

3. The importance of forming computer graphics competence of future vocational education teachers. // Bulletin of the Abai Kazakh National University of Education. Series “Pedagogical Sciences”, No. 3(79), 2023.- P.167-179. <https://doi.org/1.51889/2959-5762.2023.79.3.014> (Sh.A. Bitemirova, S.A. Zholdasbekova, B.T. Makhmetova doctoral share – 45%).

4. Methods and approaches to teaching STEM technologies. // Bulletin of the Abai Kazakh National University. Series "Physical and Mathematical Sciences", Vol. 83 No. 3, 2023.- P. 227-236. DOI 10.51889/2959-5894.2023.83.3.025 (Berkimbayev K.M. doctoral student share - 90%).

5. The content of training future computer science teachers for STEM education. // Bulletin of the L.N. Gumilyov Eurasian National University. Pedagogy. Psychology. Sociology series, 4 (145),2023 P. 110-117. DOI: <https://doi>

org/10.32523/2616-6895-2023-145-4-110-120 (Berkimbayev K.M., Zhaidakbayeva L.K. doctoral student share - 90%).

6. Methodological foundations of training future computer science teachers for STEM education.// "Bulletin of the National Academy of Sciences of the Republic of Kazakhstan". P.44-62. <https://doi.org/10.32014/2024.2518-1467.85> (A.E. Abylkasymova, M.S. Karataeva, K.M. Berkimbayev doctoral student share - 90%).