

ABSTRACT
of the dissertation by Nurlan Sagynbekovich Karatayev
submitted for the degree of Doctor of Philosophy (PhD)
under the educational programme
8D01503 - Training of Computer Science Teachers

Research Topic: Theoretical and Methodological Foundations of Teaching Robotics to Primary School Students Using Digital Technologies.

Research Aim: To determine the theoretical foundations of teaching robotics to primary school students using digital technologies and to develop an effective methodology for its implementation.

Object of the Research: The process of teaching robotics to primary school students.

Subject of the Research: The methodology of teaching robotics to primary school students using digital technologies.

Research Hypothesis: *If* the theoretical and methodological foundations of teaching robotics to primary school students using digital technologies are established, and digital educational resources together with an effective instructional methodology are integrated into the educational process, then students' digital literacy, the accessibility and visualisation of learning, their interest in robotics, and their design and construction skills will improve, *since* the digital educational website and instructional tasks contribute to students' learning activities, support the development of practical experience, and ensure the interactive nature of learning.

In accordance with the research aim and hypothesis, the following **objectives** were defined:

- to determine the theoretical and methodological foundations of teaching robotics to primary school students;
- to identify the didactic potential and methodological features of teaching robotics using digital technologies;
- to develop the Robo-Baldyrgan digital educational resource based on the educational programme;
- to develop the content and methodology for teaching robotics to primary school students and to verify their effectiveness through a pedagogical experiment.

Leading Idea of the Research. The use of curriculum-based instructional content delivered through digital technologies in robotics education for primary school students contributes to greater student engagement and interest, the development of digital literacy and digital competence, the improvement of practical skills, increased accessibility and visibility of learning, more active participation in educational activities, and the acquisition of practical experience.

Methodological and Theoretical Foundations of the Research. The methodological and theoretical foundations of the study are based on the theory of cognition and activity theory within the context of the research area. The theoretical framework draws upon philosophical, psychological, and pedagogical studies devoted to robotics education for primary school students. The methodological basis of the research comprises learner-centred, activity-based, competence-based,

systemic, and digital approaches to education. The study also draws on the theory of educational informatization, concepts concerning the application of digital technologies in the educational process, constructivist theory, and the pedagogical foundations of robotics education.

Research Sources. The regulatory foundation supporting teacher education in the field of education comprised official documents governing continuous teacher education from both regulatory and methodological perspectives, including education laws, state concepts, educational programmes, strategic policy documents, and other regulatory acts. The theoretical foundation of the research was formed by national and international scholarly works on robotics education in primary schools, as well as educational websites.

Research Methods:

– Theoretical methods: analysis, comparison, and synthesis of psychological, pedagogical, and methodological literature, educational standards, and curricula related to the problem of robotics education in primary schools;

– Empirical methods: observation, questionnaires, testing, verification of the research hypothesis through a pedagogical experiment, and assessment of knowledge, skills, and competencies;

– Statistical methods: quantitative processing of the results of the pedagogical experiment, comparative analysis of the data obtained, and evaluation of the effectiveness of the research outcomes.

Research Base: The experimental study was conducted in the primary grades of Municipal State Institution A. Navoi General Secondary School No. 11 and Municipal State Institution Lermontov General Secondary School No. 17, both operating under the Department of Education of the city of Shymkent.

Scientific Novelty of the Research:

– the theoretical and methodological foundations of teaching robotics to primary school students have been refined;

– the didactic potential and methodological features of teaching robotics using digital technologies have been identified;

– the Robo-Baldyrgan digital educational resource based on the educational programme has been developed;

– the content and methodology for teaching robotics to primary school students have been developed, and their effectiveness has been verified through a pedagogical experiment.

Theoretical Significance of the Research. The findings contribute to the further development of the pedagogical and methodological foundations of teaching robotics to primary school students using digital technologies. In addition, they contribute to a more precise understanding of the scientific and methodological aspects of integrating robotics into primary education and provide a rationale for the pedagogical potential of developing students' digital competence.

The methodology for teaching robotics to primary school students developed within this dissertation research may be used by teachers in educational institutions during classroom instruction, in supplementary education programmes, and in the delivery of elective courses.

Practical Significance of the Research. The study resulted in the development of teaching and methodological materials, a system of instructional tasks, and the Robo-Baldyrgan educational website designed for teaching robotics to primary school students and based on the educational programme. The proposed methodology may be applied in primary schools, supplementary education institutions, and teacher education programs. The practical significance of the research lies in the development of the Robo-Baldyrgan educational website for teaching robotics to primary school students, the methodology of the elective course Secrets of Robots, the teaching and methodological guide Robotics in Primary School, and a set of instructional tasks intended for use in the educational process, as well as in identifying effective approaches to the practical integration of robotics into teaching and learning.

Key Provisions Submitted for Defence:

1. Teaching robotics to primary school students through the use of digital technologies contributes to the development of algorithmic thinking, digital literacy, intellectual curiosity, and learning engagement, and also contributes to the development of a creative personality.

2. The systematic use of digital educational resources in robotics instruction increases the effectiveness of the educational process and makes a substantial contribution to the expansion of students' practical learning activities.

3. Curriculum-based instructional content increases primary school students' interest in robotics and promotes the development of their creative and cognitive abilities.

4. The findings of the experimental study confirm the effectiveness of the proposed methodology for organising robotics instruction for primary school students, validate the research hypothesis, and demonstrate its applicability in educational practice.

The **author's contribution** includes determining the theoretical and methodological foundations for teaching robotics to primary school students using digital technologies; developing the Robo-Baldyrgan educational website based on national values; introducing the elective course Secrets of Robots into the educational process; evaluating the effectiveness of the proposed methodology through a pedagogical experiment; analysing the results obtained; and confirming the validity of the research hypothesis.

The **reliability and validity of the research findings** are ensured by a well-founded methodological framework for the psychological and pedagogical principles underlying the study, the use of a set of research methods aligned with its subject matter, and the implementation of the proposed methodology for teaching robotics to primary school students using digital technologies within the school subject Digital Literacy during the experimental phase of the research.

Publications Resulting from the Research.

A total of 20 scholarly publications have been produced within the scope of the dissertation research. Of these, 1 article was published in an international peer-reviewed journal indexed in the Scopus database; 3 articles were published in scientific journals recommended by the Committee for Quality Assurance in Science

and Higher Education of the Republic of Kazakhstan; 2 articles appeared in the proceedings of international scientific and practical conferences held abroad; and 7 articles were published in the proceedings of international conferences held in the Republic of Kazakhstan. In addition, 5 copyright registration certificates, 1 textbook, and 1 teaching and methodological guide were developed.

Articles published in a Scopus-indexed international journal:

1. Karatayev, N., Ibashova, A., Mamayev, K., Tenizbayev, Y., Baizakova, S., Sundetbayeva, A. Robotics as a Tool for Value-Oriented Education in Primary Schools: A Case Study in Kazakhstan // International Journal of Information and Education Technology, 2026, 16(3), Pages 805-817, [https://doi: 10.18178/ijiet.2026.16.3.2553](https://doi.org/10.18178/ijiet.2026.16.3.2553). Percentile: 65%.

Articles published in national journals recommended by the Committee for Quality Assurance in Science and Higher Education:

2. Ualikhanova B.S., Karatayev N.S. Methods of Teaching the Course “Robotics” in Primary School // Yasawi University Bulletin. – 2022. – No. 4(126). – pp. 189–199. DOI: 10.47526/2022-4/2664-0686.16.

3. Karatayev N.S., Ibashova A.B., Bulbul H.I. Teaching Robotics to Primary School Students through STEM-Based Learning // Bulletin of the National Academy of Sciences of the Republic of Kazakhstan. – 2024. – Vol. 410. – No. 4. – pp. 272–281. DOI: 10.32014/2024.2518-1467.804.

4. Karataev N.S., Bulbul Halil Ibrahim, Ualikhanova B.S. Development of Innovative Skills of Primary Class Students Through Robotics // Yasawi University Bulletin. – 2024. – No. 4(134). – pp. 389–400. DOI: 10.47526/2024-4/2664-0686.129.

Publications in other international periodicals:

5. Ibashova A.B., Belessova D.T., Karatayev N.S. The Current State and Prospects for the Development of Informatics Education in Primary Schools of the Republic of Kazakhstan // Proceedings of the International Scientific and Practical Conference Current Issues in the Methodology of Teaching Informatics and Mathematics in the Modern School. – Moscow, 2022. – pp. 684–691.

6. Karatayev N., Ibashova A. Features of Teaching Robotics to Primary School Students in the Context of Smart Education // Avrasya Sosyal ve Ekonomi Araştırmaları Dergisi. – 2023. – Vol. 10. – Special Issue in Memory of Professor Dr. Raskul Ibragimov. – pp. 15–30.

Publications in the proceedings of international conferences held in Kazakhstan:

7. Ibashova A.B., Karatayev N.S., Ualikhanova B.S. The Purpose of Teaching the Course “Robotics” in Primary School under the Updated Educational Programme // International Scientific and Practical Online Conference Modern Scientific Research: Current Issues, Achievements and Innovations. – Turkistan, 2021. – pp. 254–258.

8. Karatayev N.S., Ibashova A.B., Nakhipova V.I. Development of Learning Scenarios for the Course “Robotics” for Primary School Students // Proceedings of the International Scientific and Practical Conference Digital Technologies in Education: Challenges and Prospects. – Arkalyk, 2022. – pp. 8–12.

9. Karatayev N.S., Ibashova A.B., Moshqalov A.Q. Pedagogical Aspects of Teaching Robotics to Primary School Students in the Context of Smart Education // Abai KazNPU Bulletin. Series of Physical and Mathematical Sciences. – 2023. – Vol. 82. – No. 2. – pp. 237–245. DOI: 10.51889/2959-5894.2023.82.2.026.

10. Karatayev N.S., Ibashova A.B. The Importance of Using Virtual Laboratories in Teaching Robotics to Primary School Students // VII World Congress of Mathematicians of the Turkic World. – Turkistan, 2023. – Part III. – pp. 287–295.

11. Karatayev N.S., Ibashova A.B., Shyrynkhonova D.Zh. Analysis of the Development and Current State of Robotics Education for Primary School Students // International Scientific and Practical Conference Shakarim Readings – 2024, dedicated to the 90th anniversary of Shakarim University. – Semey, 2024. – pp. 599–604.

12. Karatayev N.S., Ibashova A.B., Belessova D.T., Nurmukhambetova G.K. Opportunities for Fostering National Values among Primary School Students through Robotics // Proceedings of the International Scientific and Methodological Conference Mathematical Modelling and Information Technologies in Education and Science, dedicated to the 40th anniversary of school informatics and the 80th anniversary of Professor Ye. Y. Bidaibekov, Doctor of Pedagogical Sciences. – Almaty, 2025. – pp. 578–583.

13. Karatayev N.S., Ibashova A.B. Organising Robotics Classes in Primary School on the Basis of National Values // Proceedings of the International Scientific and Theoretical Conference Zhanibekov Readings – 3: The Phenomenon of Uzbekali Zhanibekov: Personal Legacy and Educational Values. – Shymkent, 2026. – Part I. – pp. 345–348.

Textbook and teaching and methodological guide:

14. Karatayev N.S., Ibashova A.B., Ualikhanova B.S. Robotics in Primary School: Textbook. – Shymkent: SKNPU Publishing House, 2023. – 96 p.

15. Karatayev N.S., Ibashova A.B., Ualikhanova B.S. Robotics in Primary School. Workbook: Teaching and Methodological Guide. – Shymkent: SKNPU Publishing House, 2023. – 52 p.

Copyright registration certificates:

16. Karatayev N.S., Ibashova A.B., Ualikhanova B.S. Robotics Information and Educational Environment (for Primary School Students). Certificate of Registration in the State Register of Copyright-Protected Works. 13 October 2022. – No. 29414.

17. Ibashova A.B., Karatayev N.S., Ualikhanova B.S. Robotics in Primary School: Textbook for Grade 4 Students of General Secondary Schools. Certificate of Registration in the State Register of Copyright-Protected Works. 5 October 2023. – No. 39416.

18. Karatayev N.S., Ibashova A.B., Uisinbek A.Zh., Kredina K.V. Workbook for the Elective Course “Digital Literacy”. Certificate of Registration in the State Register of Copyright-Protected Works. 2 April 2026. – No. 69425.

19. Serikbaiqyzy A., Ibashova A.B., Karatayev N.S. Robot Movement. Certificate of Registration in the State Register of Copyright-Protected Works. 16 April 2026. – No. 70337.

20. Karatayev N.S., Ibashova A.B. Educational Platform “Robobaldyrgan.kz”. Certificate of Registration in the State Register of Copyright-Protected Works. 22 April 2026. – No. 70685.

Research Stages:

Stage One (2021-2022). In line with ongoing developments in the education system, the significance of teaching robotics to primary school students using digital technologies was substantiated, and the aim, objectives, object, and subject of the research were refined. Drawing on both national and international experience, relevant materials were collected, and scientific, methodological, pedagogical, and online sources were analysed. The advantages and limitations of teaching robotics using digital technologies were identified, and questionnaire items were prepared. In addition, students’ age-related characteristics and levels of cognitive development were examined.

Stage Two (2022-2023). Based on contemporary scientific concepts and advanced pedagogical experience, a methodology for teaching robotics to primary school students using digital technologies was developed. This methodology was supplemented by the Robo-Baldyrgan educational website, designed to increase students’ interest in robotics. Within this area of work, the teaching and methodological guide Robotics in Primary School, the workbook Robotics in Primary School, the Robo-Baldyrgan educational website for primary school students, the elective course Secrets of Robots, and a system of tasks and exercises aimed at developing creativity, problem-solving skills, and teamwork skills were developed.

Stage Three (2023-2025). The results of the study were analysed and summarised. The effectiveness of the developed methodology was tested in practice, and its effectiveness was evaluated on the basis of the data obtained. The theoretical and experimental materials were refined, final conclusions were formulated, and practical recommendations were developed.

Structure and Content of the Dissertation. The dissertation consists of an introduction, two chapters, a conclusion, a list of references, and appendices.

The **introduction** substantiates the relevance of the research and defines the main components of the research framework, including the aim, object and subject of the study, the research hypothesis, objectives, and research methods. It also presents the scientific novelty of the research, its theoretical and practical significance, the key provisions submitted for defence, information on the publication of research results, and a description of the research base and stages of the study.

The first chapter, “**Theoretical and Methodological Foundations of Teaching Robotics to Primary School Students Using Digital Technologies,**” examines the role and potential of robotics education in primary schooling, its didactic opportunities and methodological features, and substantiates the need for the integration of digital educational resources. It also analyses the curriculum load of the subject Digital Literacy, including the content of the Robotics unit.

The second chapter, “**Methodology for Teaching Robotics to Primary School Students Using Digital Technologies,**” examines the aims and content of robotics education for primary school students, teaching methods and techniques, and forms of learning organisation based on the Robo-Baldyrgan educational website

designed for robotics instruction. In addition, the chapter presents the results of the experimental evaluation of the proposed methodology and describes the organisation of the experimental study.

The **conclusion** summarises the main findings of the research, analyses the extent to which the research hypothesis and the key provisions submitted for defence have been confirmed, and presents practical recommendations based on the results obtained.

The **list of references** includes philosophical, psychological, and pedagogical works related to the research topic.

The **appendices** contain the diagnostic instruments used during the experimental study, the content of the elective course Secrets of Robots designed for teaching robotics to primary school students using digital technologies, as well as supplementary materials not included in the main body of the dissertation.

The dissertation and its implementation within the educational process were carried out as part of Project AP09260464 – Development of an Information and Educational Environment for Primary School Courses “Scratch” and “Robotics” in the Context of Smart Education, funded by the Ministry of Education and Science of the Republic of Kazakhstan. In addition, the research is being conducted within the framework of Project AP25794885 – Formation of National Values among Primary School Students through Robotics, implemented under the Zhas Galym grant programme for 2025-2027.