

ABSTRACT

of the dissertation by Dariga Azimbayeva, submitted for the degree of Doctor of Philosophy (PhD) in the educational program 8D01201 - Preschool Education and Upbringing at Abai Kazakh National Pedagogical University, on the topic «Formation of Algorithmic Skills in Preschool Children in the Process of Teaching the Basics of Mathematics»

Research topic: Formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics.

Research objective: to provide a theoretical and methodological substantiation and to develop a methodological complex for the formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics, as well as to test its effectiveness through experimental work.

Research objectives:

1. To reveal the scientific and theoretical foundations for the formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics.

2. To determine the potential for forming algorithmic skills in preschool children in the process of teaching the basics of mathematics.

3. To develop a structural-content model for the formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics.

4. To develop a methodological complex for the formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics and to test its effectiveness through experimental work.

Object of the research: the process of forming algorithmic skills in preschool children.

Subject of the research: the methodology for developing algorithmic skills in preschool children in the process of teaching the basics of mathematics.

Research methods: To achieve the stated objectives and test the scientific hypothesis, an interconnected set of theoretical, empirical, and mathematical-statistical methods was used. Theoretical methods included analysis of philosophical, psychological, pedagogical, and methodological literature devoted to the formation of algorithmic skills, the mathematical development of preschool children, and teaching the basics of mathematics; content analysis of regulatory documents; comparison, systematization, classification, generalization, pedagogical modeling, and theoretical substantiation of the research findings. Empirical methods included observation, conversation, questionnaires, diagnostic tasks and play situations, analysis of the results of children's activities, organization of a pedagogical experiment, and evaluation of its results. Mathematical-statistical methods included quantitative and qualitative processing of data obtained during the experimental work, calculation of percentage indicators, comparative analysis, and systematization of the research results using tables and diagrams.

Main provisions submitted for defense (proven scientific hypotheses and other statements constituting new knowledge):

1. Based on the genesis and scientific integration of the problem of forming algorithmic skills in preschool children, the essence, content, and structure of algorithmic

skills have been specified. Algorithmic skills of preschool children are defined as an integrative personal-cognitive structure formed in the process of teaching the basics of mathematics and reflecting the unity of abilities to purposefully plan actions, maintain the sequence of their execution, predict results, exercise control and evaluation, and apply acquired skills adaptively in changing situations. Its scientific foundation comprises the logical principles of cognition, the regularities of cognitive and cultural-historical development, theories of activity-based and developmental learning, algorithmization and computational thinking, as well as educational ideas grounded in national values. At the same time, the psychological and pedagogical prerequisites, content, means, and organizational forms for the formation of algorithmic skills have been systematized, and the pedagogical potential of play-based, practical, visual-modeling, and collaborative activities has been substantiated.

2. The potential of the process of teaching the basics of mathematics for the formation of algorithmic skills in preschool children has been identified. This potential is defined through the interrelationship of cognitive-intellectual, sensory, research, play-and-activity, creative, social-communicative, logical-mathematical, spatial-temporal, and algorithmic opportunities. It has been substantiated that the systematic organization of mathematical-content tasks and play activities enables children to develop skills in comparison, grouping, matching, identifying patterns, maintaining the sequence of actions, executing and constructing algorithms, and applying them in new situations. The methodological foundations for the formation of algorithmic skills were identified as the axiological, personality-oriented, systemic, integrative, cognitive, innovative-creative, and activity-based approaches, along with the principles of value orientation, agency, systematicity, integration, awareness, creative independence, and active engagement.

3. A structural-content model for the formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics has been developed. The model is built on the unity of the target, theoretical, methodological, structural-content, procedural, and level-and-result blocks and is based on systemic, activity-based, cognitive, personality-oriented, and axiological approaches, as well as the principles of scientific validity, systematicity and consistency, visibility, accessibility, activity, and orientation toward national values. Within the model, the motivational, cognitive, activity-based, and reflexive components of algorithmic skills, together with their criteria, indicators, and levels of formation (low, medium, high), are systematized in an interconnected manner. The proposed model is regarded as an effective pedagogical system integrating the content, methods, forms, means, and expected outcomes of the phased formation of algorithmic skills in the process of teaching the basics of mathematics.

4. A methodological complex aimed at forming algorithmic skills in preschool children has been developed, and its effectiveness has been confirmed by the results of the experimental work. The methodological complex includes the program for preschool educators «Алгоритмдік дағдылар әліппесі» («The ABC of Algorithmic Skills»), the teaching and methodological manual for students of pedagogical specialties and preschool educators «Қадамнан қадамға: мектеп жасына дейінгі балалардың алгоритмдік дағдыларын дамыту» («Step by Step: Developing Algorithmic Skills in Preschool Children»), and the collection of algorithmic games for preschool children «Алгоритм әлемі» («World of Algorithms»). The complex is proposed as a system of effective

pedagogical tools that foster children's interest in algorithmic tasks, understanding of mathematical-task conditions, performance of actions in the required sequence, construction of algorithms, verification of results, and explanation of their own actions. The experimental results showed that the systematic use of the methodological complex increases the level of algorithmic skills formation in children of pre-primary groups.

Description of the main research results: The reliability and validity of the research results are confirmed by the correspondence of the research framework to the aim and content of the study, the systematization of the theoretical and methodological foundations, the development of the structural-content model for the formation of algorithmic skills, confirmation of the effectiveness of the methodological complex through experimental work, mathematical-statistical processing of the obtained data, positive dynamics in the indicators of the experimental and control groups, and practical confirmation of the research hypothesis.

Substantiation of the novelty and significance of the obtained results:

Result 1 is novel. From an integrated scientific perspective, based on the genesis and scientific integration of the problem of forming algorithmic skills in preschool children in the process of teaching the basics of mathematics, the essence, content, and structure of the formation of algorithmic skills have been specified. The formation of algorithmic skills is defined on the basis of the mutual integration of the theory of cognition, cognitive development theory, cultural-historical theory, activity theory, the theory of the phased formation of mental actions, developmental learning theory, preschool education theory, play theory, ideas of national education, algorithm theory, and computational thinking theory. The substantiated theoretical provisions demonstrated that algorithmic skills are formed in interrelation with logical-mathematical thinking and the processes of planning, execution, control, evaluation, and reflection on activity. As a result, a system of original definitions has been developed for the concepts of «algorithmic ability», «algorithmic potential», «algorithmic thinking», «algorithmic skill», and «algorithmic culture»; their scientific and pedagogical content and interrelationships have been specified. The significance of the result lies in the possibility of providing a comprehensive theoretical explanation of the process of forming algorithmic skills in preschool children and systematizing the conceptual framework of the study.

At the same time, the psychological and pedagogical prerequisites for the formation of algorithmic skills in preschool children have been identified in relation to the child's age characteristics, cognitive processes, practical activity, self-control, and the system of pedagogical support. The means and organizational forms for forming algorithmic skills in the process of teaching the basics of mathematics have been systematized, and the pedagogical potential of play-based, practical, visual-modeling, and collaborative activities has been substantiated.

Result 2 is novel. The potential for forming algorithmic skills in preschool children in the process of teaching the basics of mathematics has been identified. The study specified the cognitive-intellectual, sensory, research, activity-and-play, creative, social-communicative, logical-mathematical, spatial-temporal, and algorithmic components of this potential and scientifically substantiated their interrelationship. It has been demonstrated that activities included in the content of the basics of mathematics, such as counting, comparison, grouping, matching, orientation in space and time, and

identification of patterns, enable children to understand task conditions, plan the sequence of actions, execute an algorithm, check the result, correct errors, and explain their actions. The methodological foundations for forming algorithmic skills were identified as the systemic, activity-based, cognitive, personality-oriented, and axiological approaches, as well as the principles of scientific validity, systematicity and consistency, visibility, accessibility, activity, and orientation toward national values.

Result 3 is novel. A structural-content model for the formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics has been developed. The model is constructed as an integral pedagogical system combining interconnected target, theoretical, methodological, structural-content, procedural, and level-and-result blocks. The study identified and systematized in their interrelationship the motivational, cognitive, activity-based, and reflexive components of the formation of algorithmic skills in teaching the basics of mathematics, together with the corresponding criteria, indicators, and levels of formation (low, medium, high). In addition, methodological approaches, didactic principles, stages, organizational forms, methods, means, and expected outcomes of algorithmic-skills formation in teaching the basics of mathematics were integrated, and pedagogical mechanisms for their purposeful, systematic, and phased implementation were determined.

Result 4 is novel. A methodological complex intended for the formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics has been developed. It includes the program «Алгоритмдік дағдылар әліппесі» («The ABC of Algorithmic Skills»), the teaching and methodological manual for preschool educators «Қадамнан қадамға: мектеп жасына дейінгі балалардың алгоритмдік дағдыларын дамыту» («Step by Step: Developing Algorithmic Skills in Preschool Children»), and the collection of algorithmic games for preschool children «Алгоритм әлемі» («World of Algorithms»). As a result of the study, the content of the methodological complex was structured as a pedagogical system comprising program and teaching-methodological materials, as well as national, didactic, logical, movement-based, digital, and algorithmic games aimed at the integrated formation of the motivational, cognitive, activity-based, and reflexive components of algorithmic skills. The results of the experimental work confirmed the effectiveness of the systematic use of the methodological complex in the process of teaching the basics of mathematics for increasing the level of algorithmic skills formation in children of pre-primary groups. On this basis, the methodological complex was proposed as an effective pedagogical tool for forming algorithmic skills in preschool children and was introduced into the educational process of preschool organizations.

Compliance with the directions of scientific development or state programs: The dissertation research was conducted in accordance with the priority directions of state policy aimed at developing the education system of the Republic of Kazakhstan and with the current regulatory documents. In particular, the study was guided by the tasks of modernizing education and upbringing outlined in the speech of President Kassym-Jomart Tokayev at the fifth meeting of the National Kurultai; the Laws of the Republic of Kazakhstan «On Education» and «On the Rights of the Child»; the UN Convention on the Rights of the Child; the «State Compulsory Standard for Preschool Education and Training»; the Model Curriculum for Preschool Education and Training and its guidelines;

the initiative of the Ministry of Education of the Republic of Kazakhstan «Quality Education Accessible to Everyone»; the Resolution of the Government of the Republic of Kazakhstan «On Approval of the Model for the Development of Preschool Education and Training»; the Concept for the Development of Preschool, Secondary, Technical and Vocational Education in the Republic of Kazakhstan for 2023-2029; Resolution of the Government of the Republic of Kazakhstan No. 56 dated January 29, 2026 «On Approval of the Concept “Children of Kazakhstan” for 2026-2030»; and the Code of Ethics for Educational Researchers of the Republic of Kazakhstan.

Doctoral candidate's contribution to the preparation of each publication (the dissertation author's contribution is indicated as a percentage of the total volume of each publication): A total of 10 scholarly works have been published on the dissertation topic, including 1 teaching and methodological manual and 1 collection of games; 1 article was published in an international scientific journal indexed in the Scopus database (Q2 quartile, CiteScore percentile - 52). In addition, 2 articles were published in scientific 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, and 5 articles were published in the proceedings of international scientific and practical conferences.

1. *Modular learning for preparing preschool teachers to develop algorithmic skills in early childhood*. International Journal of Evaluation and Research in Education (IJERE), Vol. 15, No. 2, April 2026, pp. 1539-1550. ISSN: 2252-8822, DOI: 10.11591/ijere.v15i2.37826. Percentile - 52%.

The article examines the effectiveness of modular learning technology in preparing future preschool educators to develop algorithmic skills in preschool children. It presents the effective aspects of the integrated use of theory, practice, and reflection in enhancing the professional competence of future educators, their confidence in applying algorithmic skills, and their ability to organize practical activities. Doctoral candidate's contribution - 70%. (Co-authors: U. Kyyakbayeva, G. Shirinbayeva, S. Yerkebayeva, A. Kosshygulova, G. Abilbakieva, N. Atemkulova).

2. *Content-and-Activity Component of the Methodology for the Formation of Algorithmic Skills in Preschool Children* // Bulletin of Abai KazNPU, Series «Pedagogical Sciences», No. 2 (86). - Almaty, 2025. - pp. 324-332. <https://doi.org/10.51889/2959-5762.2025.86.2.029>.

The article examines the content-and-activity component of the methodology for forming algorithmic skills in preschool children. It describes the content, types of activities, a system of play-based tasks and practical exercises that facilitate children's mastery of algorithmic actions, and methodological approaches to their use in the process of teaching the basics of mathematics. Doctoral candidate's contribution - 80%. (Co-authors: S.A. Nurgaliyeva, V.V. Atabekova).

3. *Pedagogical conditions for the formation of algorithmic skills in preschool children in the process of teaching the basics of mathematics* / Bulletin of Ablai Khan KazUIRandWL, Series «Pedagogical Sciences», Almaty, No. 3 (78), 2025, pp. 601-616. <https://doi.org/10.48371/PEDS.2025.78.3.037>.

The article scientifically substantiates the pedagogical conditions necessary for the formation of algorithmic skills in preschool children in the process of teaching the basics

of mathematics. It demonstrates the possibilities for effective formation of algorithmic skills through consideration of children's age characteristics, organization of a developmental play environment, pedagogical support, and the introduction of reflexive activity. Doctoral candidate's contribution - 80%. (Co-authors: U.K. Kyyakbayeva, A.K. Aitpayeva).

4. *Development of Universal Prerequisites for Learning Activities in Preschool Children through the Formation of Algorithmic Skills* // International Scientific Journal «Endless Light in Science». No. 1, January 31, 2025. - Almaty, Kazakhstan, pp. 127-133. DOI: 10.24412/2709-1201-2025-31-127-132.

The article examines the development of universal prerequisites for learning activities in preschool children through the formation of algorithmic skills and presents ways to develop personal qualities necessary for adaptation to school learning. Doctoral candidate's contribution - 90%. (Co-author: U.K. Kyyakbayeva).

5. *Formation of Algorithmic Skills in Preschool Children* // Materials of the X International Scientific-Practical Conference “Integration of the Scientific Community to the Global Challenges of Our Time”. In three volumes. Volume II - Marseille (France): Regional Academy of Management, February 5-7, 2025. - pp. 212-218. ISBN 978-601-267-055-4.

The article examines the psychological and pedagogical prerequisites for the formation of algorithmic skills in preschool children depending on their age characteristics. It presents ways of gradually developing skills in maintaining sequence, following rules, carrying out instructions, and understanding the goal and plan of actions in children's everyday, play, and cognitive activities. Doctoral candidate's contribution - 80%. (Co-authors: U.K. Kyyakbayeva, G.K. Shirinbayeva).

6. *Methodology for the formation of algorithmic skills of preschool children* / VII International Research Congress on Social Sciences (USOBAK), May 06-07, 2025. - pp. 68-74. / Organized by Gazi University and Ankara Hacı Bayram Veli University, Ankara/Türkiye. ISBN 978-605-82037-9-2.

The article examines the content and structure of the methodology for forming algorithmic skills in preschool children. The cognitive, regulatory, and communicative components of algorithmic skills are analyzed, and ways of developing them through integrated tasks are presented. Doctoral candidate's contribution - 80%. (Co-authors: U.K. Kyyakbayeva, Y. Gelişli).

7. *Developing algorithmic skills in preschool children through play* // Proceedings of the International Scientific Forum «Modern Preschool Education: Experience and Prospects», dedicated to the 70th anniversary of Doctor of Pedagogical Sciences, Professor A.E. Mankesh. / April 11, 2025 / Abai Kazakh National Pedagogical University. - Almaty: Abai KazNPU, 2025. - pp. 22-25. ISBN 978-601-353-356-8.

The article examines the formation of algorithmic skills in preschool children through play. Play activity is characterized as an effective means for the phased completion of tasks, systematic organization of simple and complex actions, and understanding the path toward achieving a result. Doctoral candidate's contribution - 90%. (Co-author: U.K. Kyyakbayeva).

8. *Quest Game as a Means of Forming Algorithmic Skills in Preschool Children* // Proceedings of the international networking event «Tuning in Education: Trends in the

Development of Global Experience at the Intersection of Didactics, Psychodidactics, Sociodidactics, Cyberdidactics and Neurodidactics», dedicated to the 95th anniversary of the scholar-didactician, Doctor of Pedagogical Sciences, Professor Talgat Sabyrzhanuly Sabyrov, April 12, 2024. - Almaty: KazNPU. - pp. 130-133. ISBN 978-601-353-269-1.

The article presents the quest game as an effective means of forming algorithmic skills in preschool children. The essence of the concepts «algorithm» and «quest» is revealed, and the types of quest games and requirements for their organization are described. Doctoral candidate's contribution - 90%. (Co-author: G.K. Shirinbayeva).

9. *Collection of Algorithmic Games for Children of the Pre-Primary Group «World of Algorithms»* / comp. by D.K. Azimbayeva, U.K. Kyyakbayeva. - Almaty: Qazaq University, 2026. - 240 p. ISBN 978-601-04-7564-9.

The game collection «World of Algorithms» is intended to develop algorithmic skills in children of the pre-primary group. The collection presents a system of problem-based games, games with rules, games with incomplete sequences of actions, quest games, graphic dictations, and games with national content aimed at developing children's skills in performing actions in a specific sequence, understanding task conditions, making decisions, checking results, and explaining their own actions. The collection is intended for preschool educators, students of higher education institutions and pedagogical colleges, as well as parents. Doctoral candidate's contribution - 80%. Co-author: U.K. Kyyakbayeva.

10. *Teaching and Methodological Manual for Preschool Educators «Step by Step: Developing Algorithmic Skills in Preschool Children»* / D.K. Azimbayeva, U.K. Kyyakbayeva. - Almaty, 2026. - 300 p.

The teaching and methodological manual is intended for preschool educators and aims to provide methodological support for the phased development of algorithmic skills in preschool children in the process of teaching the basics of mathematics. The manual covers the theoretical foundations of algorithmic-skills development, methodological approaches, a system of games and tasks, methodological recommendations for educators, and diagnostic materials. Doctoral candidate's contribution - 80%. Co-author: U.K. Kyyakbayeva.