

# Effectiveness of Developing Logical Thinking Based on The Montessori Method in Preschool Educational Organizations

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## ABSTRACT

This article examines the effectiveness of developing logical thinking in preschool children through the Montessori method in preschool educational organizations. In the context of the modernization of preschool education systems, the implementation of innovative pedagogical technologies aimed at the comprehensive development of a child's personality has become increasingly important. The Montessori method is a humanistic educational approach based on the principles of independent activity, freedom of choice, individualized learning pace, and a specially prepared learning environment. The use of Montessori didactic materials promotes the development of children's abilities to analyze, compare, classify, identify cause-and-effect relationships, generalize information, and make independent decisions, all of which are essential components of logical thinking. The article analyzes the theoretical foundations of the Montessori method, identifies the pedagogical conditions necessary for its effective implementation in preschool educational institutions, and presents the results of practice-oriented learning activities designed to enhance children's intellectual abilities. Particular attention is given to the role of the teacher as the organizer of a stimulating educational environment that encourages cognitive activity, independence, and active learning. The findings indicate that the systematic use of Montessori materials has a positive impact on the development of cognitive processes, improves children's concentration, strengthens research and problem-solving skills, enhances mathematical understanding, and promotes the development of logical reasoning. The study concludes that integrating the Montessori method into the educational process of preschool institutions is an effective means of fostering logical thinking and preparing children for successful learning at subsequent stages of education.

**Keywords:** Montessori method, logical thinking, preschool education, learning environment, cognitive activity, didactic materials, intellectual development, pedagogical effectiveness.

## INTRODUCTION

The modern preschool education system is focused on developing an intellectually advanced, independent, and creatively thinking individual who is capable of successfully adapting to the rapidly changing conditions of contemporary society. In the context of globalization, the digitalization of the educational environment, and increasing requirements for the quality of children's preparation, particular importance is attached to the development of logical thinking as early as the preschool stage. It is during this age period that the foundations of intellectual activity are established, initial concepts about

the surrounding world are formed, and cognitive processes such as attention, memory, imagination, analysis, synthesis, comparison, and generalization develop. The development of these abilities is an essential condition for a child's successful learning at subsequent levels of education.

One of the most effective pedagogical approaches aimed at the comprehensive development of a child's personality is the Montessori methodology. This educational system has become widespread in many countries due to its humanistic orientation, individualized approach to each

child, and organization of a specially prepared educational environment. The fundamental principle of the methodology is to provide children with freedom of choice in activities while maintaining pedagogical guidance, which contributes to the development of independence, responsibility, and sustained cognitive motivation.

In preschool education organizations of the Republic of Uzbekistan, particular attention is being paid to the implementation of modern educational technologies that meet international quality standards. State programs for the modernization of preschool education provide for the use of innovative pedagogical methods that promote the development of children's intellectual potential, logical thinking, communication skills, and creative abilities. In this regard, the Montessori methodology is considered one of the promising technologies that enables the educational process to be effectively organized while taking into account the age-related and individual characteristics of children.

The development of logical thinking through Montessori didactic materials is based on the gradual complication of cognitive tasks. Specialized materials enable children to independently perform activities involving sorting, classification, comparison, measurement, sequencing, and identification of patterns. In the course of such activities, children learn to analyze the information they receive, draw conclusions, identify cause-and-effect relationships, and make independent decisions. A distinctive feature of this methodology is that new knowledge is acquired through practical activity, active interaction with the material environment, and the child's own experience.

Contemporary psychological and pedagogical research confirms the close relationship between the development of logical thinking and successful subsequent school education. A high level of development of logical operations contributes to faster acquisition of mathematical concepts, development of speech activity, improvement of problem-solving skills, and formation of research-oriented activity. Therefore, creating conditions for the systematic development of logical thinking is one of the priority tasks of teachers working in preschool educational organizations.

Despite the widespread use of the Montessori methodology in global educational practice, the issues of assessing its effectiveness in developing the logical thinking of preschool children within the national education system

remain insufficiently studied. Further scientific substantiation of the pedagogical conditions that ensure the maximum effectiveness of this technology is required, as well as an analysis of the factors influencing the development of children's intellectual abilities [1–4].

The purpose of this study is to determine the effectiveness of applying the Montessori methodology for developing logical thinking in children in preschool education organizations, identify the pedagogical conditions for the successful implementation of this technology, and assess its influence on the development of preschool children's cognitive activity, independence, and intellectual abilities.

## **LITERATURE REVIEW**

The development of logical thinking in preschool children is one of the priority areas of contemporary pedagogical science. Research conducted by national and international scholars indicates that the preschool period is when the fundamental intellectual abilities necessary for a child's successful further education are formed. Therefore, the search for effective pedagogical technologies that promote analytical abilities, cognitive activity, and independent thinking is of particular relevance.

The founder of the pedagogical approach under consideration is Maria Montessori, who developed a humanistic educational system based on freedom of choice, an individualized pace of learning, and a specially prepared developmental environment (Montessori, 1964). According to the author, children possess a natural need for self-development, while the teacher's task is to create conditions that allow the intellectual potential of the individual to be fully realized. In her subsequent work, *The Discovery of the Child* (Montessori, 1967), Montessori emphasized that the use of specially designed didactic materials contributes to the development of logical operations, sensory perception, independence, and concentration.

A significant contribution to the scientific substantiation of the effectiveness of the Montessori methodology was made by Angeline Lillard. In her monograph *Montessori: The Science Behind the Genius* (Lillard, 2017), the results of numerous experimental studies are presented, confirming the positive influence of the Montessori methodology on the development of executive functions, cognitive flexibility, logical thinking, and children's academic achievement. The author notes that the Montessori

educational environment promotes the development of independent analysis, decision-making skills, and intrinsic learning motivation.

The practical aspects of implementing this pedagogical technology are discussed in detail in Paul P. Lillard's work *Montessori Today* (Lillard, 1996). The researcher emphasizes that the effectiveness of the methodology is determined not only by the use of specialized materials but also by adherence to the fundamental principles of Montessori pedagogy: respect for the individuality of the child, freedom of choice, independent work, and minimal adult intervention in the learning process.

The theoretical foundations of the development of logical thinking were further developed in the works of Jean Piaget. According to the theory of cognitive development (Piaget & Inhelder, 1969), the preschool period is characterized by intensive development of intellectual operations, which emerge through the child's active interaction with the surrounding environment. Piaget regarded thinking as the result of the child's own cognitive activity, which is largely consistent with the philosophy of the Montessori method.

The cultural-historical theory of L. S. Vygotsky (1978) had a substantial influence on contemporary research. According to this theory, intellectual development takes place through joint activity between the child and the adult. The concept of the zone of proximal development emphasizes the necessity of pedagogical support that enables the child to gradually transition to independent performance of cognitive tasks. Despite the differences between Vygotsky's and Montessori's approaches, contemporary researchers note their complementary nature in organizing educational processes in preschool education.

The ideas of active learning were further developed in the research of Jerome Bruner (1960), who substantiated the need to organize learning through practical activity, exploration, and independent discovery of new knowledge. His concept of discovery learning largely corresponds to the principles of the Montessori methodology, in which the child acts as an active participant in the educational process.

Contemporary research on child development, presented in the work of Laura E. Berk (2018), confirms that the effectiveness of logical thinking development is

determined by the comprehensive influence of the educational environment, pedagogical methods, and age-related characteristics of the child's development. The author emphasizes the importance of integrating sensory experience, play-based activities, and inquiry-based learning for the development of sustainable cognitive competencies.

Contemporary international documents also confirm the need to introduce innovative technologies in preschool education. The recommendations of the National Association for the Education of Young Children (NAEYC, 2022) emphasize that a developmental educational environment should ensure children's active participation in cognitive activities, stimulate independence, critical thinking, and problem-solving abilities. A similar position is reflected in UNICEF (2017), which considers early childhood development to be a foundation for developing an individual's intellectual potential and ensuring successful subsequent learning.

Thus, the analysis of the scientific literature demonstrates that the majority of contemporary studies confirm the effectiveness of the Montessori methodology in developing logical thinking among preschool children. At the same time, the analysis of publications indicates an insufficient number of studies devoted to a comprehensive assessment of the effectiveness of this technology within the preschool education system of the Republic of Uzbekistan. This determines the scientific significance of the present study and highlights the need for further investigation of the pedagogical conditions for the successful application of the Montessori methodology in preschool educational practice.

## **METHODS**

The methodological foundation of this study consists of contemporary scientific approaches in the fields of preschool pedagogy, developmental psychology, learner-centered education, and Maria Montessori's pedagogical technology. The study is based on systemic, activity-based, competency-based, and learner-centered approaches, which ensure a comprehensive examination of the process of developing logical thinking in preschool children.

The systemic approach made it possible to consider the development of logical thinking as an integrated pedagogical process involving interconnected components: the educational environment, pedagogical

support, didactic materials, the child's independent activity, and interaction among participants in the educational process. The activity-based approach focused the study on children's active participation in practical tasks aimed at developing cognitive operations through specially designed Montessori materials. The competency-based approach facilitated the assessment of the level of intellectual competencies necessary for children's successful preparation for school education [5].

A set of complementary scientific research methods was employed. Theoretical methods included analysis of national and international scientific literature, comparative analysis of pedagogical concepts, generalization of the results of previous studies, systematization of scientific sources, and interpretation of contemporary approaches to the development of logical thinking in preschool children. Particular attention was given to scientific works addressing the application of the Montessori methodology in preschool education.

The empirical component of the study included pedagogical observation, analysis of children's educational activities, diagnostic tasks, a pedagogical experiment, and qualitative and quantitative analysis of the obtained results. During the observation process, children's ability to compare objects, classify items, establish sequences, analyze characteristics, solve logical problems, and independently identify ways of completing tasks was assessed.

The study employed the main Montessori didactic materials, including cylinder blocks, the Pink Tower, the Brown Stair, Red Rods, the Geometric Cabinet, color tablets, mathematical materials, cards for classifying objects, and logical exercises of varying levels of complexity. All materials were used in accordance with children's age-related characteristics and the principle of gradually increasing the complexity of cognitive activity.

The organization of the study consisted of several consecutive stages. At the first stage, scientific literature was analyzed, and the research objectives, tasks, and criteria for assessing the level of logical thinking were determined. At the second stage, a prepared educational environment was organized in accordance with the principles of the Montessori methodology; appropriate didactic materials were selected and practical tasks were developed. At the third stage, systematic work with children was carried out through individual and small-group activities, during which conditions were created for independent choice of activities and completion of logical exercises. The final stage of the study focused on analyzing the obtained results, their statistical processing, comparison of initial and final indicators, and formulation of scientifically grounded conclusions.

In assessing the effectiveness of the methodology, qualitative and quantitative indicators characterizing the level of logical thinking development were used. The main criteria included the ability to analyze and synthesize information, classify objects according to specified characteristics, establish cause-and-effect relationships, perform seriation, identify patterns, make independent decisions, and substantiate conclusions. The obtained data were interpreted using descriptive statistics and comparative analysis, which made it possible to objectively assess the influence of the Montessori methodology on the intellectual development of preschool children.

The use of a comprehensive methodology ensured the scientific reliability of the study, objectivity in interpreting the results, and the possibility of applying the findings in the activities of preschool educational organizations. The proposed methodology can serve as a basis for improving the educational process aimed at developing logical thinking, cognitive activity, and intellectual independence among preschool children [6, 7].

#### **Dynamics of Children's logical thinking indicators when using the montessori methodology**

**Table 1.**

| No. | Assessment Criterion               | Before the Experiment (%) | After the Experiment (%) | Change (+/-) |
|-----|------------------------------------|---------------------------|--------------------------|--------------|
| 1   | Ability to analyze                 | 54                        | 83                       | +29          |
| 2   | Ability to compare and distinguish | 58                        | 86                       | +28          |

|   |                                              |      |      |       |
|---|----------------------------------------------|------|------|-------|
| 3 | Classification skills                        | 56   | 88   | +32   |
| 4 | Establishing sequences                       | 52   | 84   | +32   |
| 5 | Understanding cause-and-effect relationships | 49   | 80   | +31   |
| 6 | Independent solution of logical problems     | 51   | 82   | +31   |
| 7 | Concentration of attention                   | 63   | 90   | +27   |
| 8 | Average indicator                            | 54.1 | 84.7 | +30.6 |

The data presented in Table 1 demonstrate the high effectiveness of applying the Montessori methodology in developing logical thinking among preschool children. Positive dynamics were observed across all the assessment criteria, confirming the significant influence of a specially organized subject-developmental environment and Montessori didactic materials on the intellectual development of children.

The most pronounced changes were observed in the indicators of “Classification skills” and “Establishing sequences,” where the increase amounted to 32%. These results can be explained by the fact that Montessori materials systematically engage children in activities involving the grouping of objects, identification of patterns, comparison of objects, and determination of sequences of actions. Such practical activities contribute to the development of analytical thinking, the ability to generalize, and the formation of logical operations.

A substantial increase was also recorded in the criteria “Understanding cause-and-effect relationships” and “Independent solution of logical problems,” which increased by 31%. This indicates that children became more confident in analyzing various situations, independently identifying ways to solve assigned problems, drawing well-founded conclusions, and applying acquired knowledge in new educational situations.

The indicator “Ability to analyze” increased from 54% to 83%, while “Ability to compare and distinguish” increased from 58% to 86%. These results confirm the effectiveness of using Montessori sensory and mathematical materials, which stimulate the development of cognitive processes, observation skills, logical reasoning, and the ability to identify essential characteristics of objects and

phenomena.

It is also important to note the increase in “Concentration of attention,” from 63% to 90%. This can be attributed to the fact that the Montessori methodology provides children with the opportunity to independently choose an activity, work at their individual pace, and complete the tasks they have started. These conditions positively influence sustained attention and the development of self-regulation skills.

The average indicator of logical thinking development increased from 54.1% to 84.7%, corresponding to an overall increase of 30.6%. The results allow us to conclude that the Montessori methodology demonstrates substantial pedagogical effectiveness in preschool education organizations. Regular use of this technology contributes to the development of logical operations, cognitive activity, independence, research skills, and children’s intellectual readiness for subsequent school education.

## RESULTS AND DISCUSSION

The results of the study indicate that the application of the Montessori methodology in preschool education organizations has a positive effect on the development of children’s logical thinking. The pedagogical experiment established that a specially organized subject-developmental environment, the use of Montessori didactic materials, and providing children with the opportunity to independently choose activities significantly increase the level of development of logical operations. The children demonstrated improvements in analysis, comparison, classification, establishing cause-and-effect relationships, seriation, and independently searching for solutions to cognitive problems.

Analysis of the results showed that the greatest positive

dynamics were achieved in children's ability to classify objects according to various characteristics and establish logical sequences. The use of materials such as the Pink Tower, Brown Stair, Red Rods, geometric figures, and Montessori mathematical materials enabled children to independently identify patterns, compare the sizes, shapes, and quantities of objects, and develop stable concepts of spatial and quantitative relationships. Performing such tasks contributed to the development of analytical thinking and the formation of logical reasoning skills.

Positive changes were also observed in the development of the ability to independently solve problem situations. Unlike the traditional learning model, in which the teacher more often acts as a source of ready-made knowledge, the Montessori methodology focuses on the child's independent search for solutions. The teacher performs the role of an organizer of the educational environment and a consultant, creating conditions for free cognitive activity. As a result, children become more proactive, gain confidence in their abilities, learn to analyze their own actions, and correct mistakes without constant assistance from an adult.

The influence of the Montessori methodology on the development of concentration and sustained cognitive activity is of particular importance. Observations showed that children maintained interest in the tasks they were performing for significantly longer periods, demonstrated a high level of concentration, and sought to complete the work they had started independently. The opportunity to choose materials and perform exercises at an individual pace reduced emotional tension and contributed to the development of intrinsic learning motivation [8].

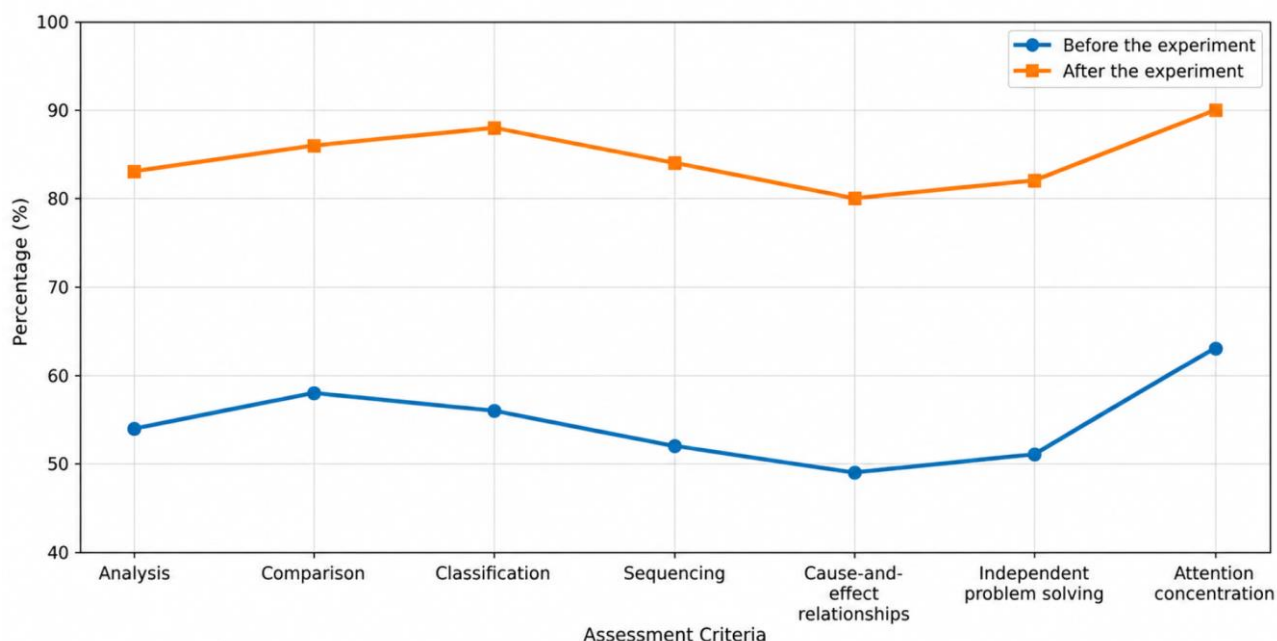
The results obtained are consistent with contemporary psychological and pedagogical research, according to which sensory experience and practical activity are essential conditions for the intellectual development of preschool children. The use of didactic materials enables children not only to acquire new knowledge but also to independently discover patterns in the surrounding world, thereby contributing to the development of critical and logical thinking. Practical activity becomes the basis for

forming strong cognitive skills necessary for successful further education at school.

It should be noted that the effectiveness of applying the methodology largely depends on teachers' professional competence and the quality of the educational environment. A prepared environment should correspond to children's age-related characteristics, provide free access to didactic materials, and stimulate independent cognitive activity. Equally important is adherence to the principles of the Montessori methodology, including respect for each child's individual pace of development, minimization of unjustified teacher intervention, and the creation of a favorable psychological atmosphere.

A comparison of the obtained results with traditional approaches to organizing the educational process indicates that the use of the Montessori methodology provides higher indicators of logical thinking development. Children master the operations of analysis and synthesis more quickly, establish cause-and-effect relationships more successfully, solve logical problems more easily, and demonstrate a higher level of independence when performing educational tasks. In addition, the methodology has a positive influence on speech development, communication skills, fine motor skills, and mathematical concepts, since all these components are closely interconnected with the process of intellectual development [9].

Thus, the results of the study confirm the substantial pedagogical effectiveness of the Montessori methodology as a means of developing logical thinking in preschool children. The systematic use of specially designed didactic materials, the organization of a subject-developmental environment, and the application of a learner-centered approach create favorable conditions for the development of children's intellectual abilities. The obtained findings support the broader implementation of the Montessori methodology in preschool education practice with the aim of improving the quality of the educational process, developing children's cognitive activity, independence, and logical thinking, and establishing a solid foundation for successful learning at subsequent levels of education [10].



**Figure 1. Comparative dynamics of the development indicators of logical thinking in preschool children under the application of the montessori methodology**

assistance from the teacher.

The results presented in Figure 1 clearly demonstrate positive dynamics in the development of logical thinking among preschool children following the implementation of the Montessori methodology. A substantial increase in indicators was observed across all the criteria studied compared with the initial level, indicating the high pedagogical effectiveness of this educational technology.

The most pronounced growth was recorded for the indicators “Classification” and “Establishing Sequences,” where the level of development of the corresponding skills increased from 56% to 88% and from 52% to 84%, respectively. These results confirm that the systematic use of Montessori didactic materials contributes to the development of analytical operations, comparison, grouping of objects, and identification of logical patterns.

A significant increase was also observed for the criteria “Understanding Cause-and-Effect Relationships” and “Independent Solution of Logical Problems,” with the indicators increasing from 49% to 80% and from 51% to 82%, respectively. This demonstrates the development of children’s ability to independently analyze situations, draw logical conclusions, establish relationships between objects, and make informed decisions without constant

The indicators “Analysis” and “Comparison” also demonstrated consistent positive dynamics. Following the pedagogical experiment, the level of analytical abilities increased from 54% to 83%, while the ability to compare objects increased from 58% to 86%. These changes confirm that the Montessori subject-developmental environment activates cognitive processes, promotes the development of observation skills, and contributes to the formation of logical operations.

Particular attention should be paid to the indicator “Attention Concentration,” which increased from 63% to 90%, representing the highest value among all the criteria examined. This result can be explained by the fact that the Montessori methodology provides freedom of choice of activities, an individual pace for completing tasks, and opportunities for repeated practice, thereby contributing to the development of sustained attention, self-control, and intrinsic learning motivation.

Overall, the comparative analysis of the data presented in Figure 1 shows that, following the application of the Montessori methodology, the level of logical thinking development among the children increased by more than

30 percentage points on average. The obtained results confirm the effectiveness of this pedagogical technology in preschool education organizations and demonstrate its considerable potential for developing children's intellectual abilities, cognitive activity, and readiness for successful learning at subsequent levels of education.

## **CONCLUSION**

The conducted study confirmed the high pedagogical effectiveness of applying the Montessori methodology to the development of logical thinking in preschool children. The obtained results indicate that a specially organized subject-developmental environment, the use of didactic materials, and the implementation of principles of independent cognitive activity have a comprehensive positive impact on the intellectual development of children.

Analysis of the results of the pedagogical experiment demonstrated a statistically significant increase in the level of development of the main components of logical thinking, including skills of analysis, comparison, classification, establishing cause-and-effect relationships, seriation, attention concentration, and independent solving of logical problems. The most pronounced positive changes were recorded in the development of classification and sequencing operations, confirming the effectiveness of the practice-oriented approach underlying the Montessori methodology.

The obtained data allow us to conclude that the Montessori educational technology not only contributes to the development of logical operations but also fosters cognitive independence, research activity, the ability to make informed decisions, and the ability to apply acquired knowledge in new educational situations. Of particular importance is the creation by the teacher of a specially prepared educational environment that ensures freedom of choice of activities, an individual pace of learning, and support for the child's natural cognitive development.

The practical significance of the study lies in the possibility of using the presented results to improve the educational process in preschool education organizations. The developed methodological approaches can be recommended for preschool teachers, methodologists, and administrators to improve the quality of educational activities aimed at developing children's intellectual potential.

The prospects for further research are associated with expanding the sample of participants, conducting long-term comparative experiments, studying the influence of individual Montessori didactic materials on different components of cognitive development, as well as integrating the Montessori methodology with modern digital educational technologies. This will make it possible to develop more effective models for the formation of logical thinking and intellectual competencies in preschool children under conditions of modernization of the education system.

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