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“NEUROPEDAGOGICAL FOUNDATIONS OF MONTESSORI ENVIRONMENT IN THE COGNITIVE DEVELOPMENT OF PRESSCHOOL CHILDREN”

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Annotation: This article explores the scientific, pedagogical, and neurobiological foundations of the Montessori method regarding the cognitive development of preschool children. Through the lens of modern neuropedagogics, the study analyzes the impact of the “prepared environment,” practical exercises, and sensory materials on the child's cerebral cortex and executive functions. The components of the method are cross-referenced with the fundamental theories of J. Piaget, L. Vygotsky, A. Luria, and N. Chomsky, scientifically substantiating the stimulation of cognitive, sensory, and linguistic processes. In conclusion, practical recommendations are put forward for integrating the neuropedagogical principles of the Montessori system into the national preschool education network within the framework of the State Requirements of the Republic of Uzbekistan.

Keywords: preschool education, Montessori method, cognitive development, neuropedagogics, prepared environment, executive functions, fine motor skills, sensory education.

“In the context of fostering the foundations of the Third Renaissance in the Republic of Uzbekistan, the modernization of the preschool education and care system stands as one of the strategic priorities of state policy. The Law of the Republic of Uzbekistan 'On Preschool Education and Care,' alongside the State Requirements for the Development of Early and Preschool Children, specifically mandates the individualized development of a child's cognitive, sensory, and linguistic potential. One of the most pressing challenges facing contemporary preschool pedagogy is designing an educational environment aligned with the laws of brain development (neuropedagogical principles). Recent advances in neurobiology and cognitive psychology reaffirm the profound scientific validity of the Maria Montessori system, which is widely implemented in international practice. This paper aims to provide a fundamental analysis of the five core cognitive areas of the Montessori methodology through the lens of modern neuropedagogics and preschool education theory, scientifically substantiating its underlying patterns in children's mental development.”

“The prepared environment, which constitutes the cornerstone of Montessori pedagogy, is not merely a material-technical base or a comfortably furnished room, but a crucial factor that stimulates the child's intellectual potential. All didactic materials, furniture, and elements within the classroom are arranged according to a specific system and strict logical order. From the perspective of modern neuropedagogics and cognitive neurobiology, this structured space directly activates the executive functions formed in the prefrontal cortex of the child's cerebral hemispheres. In her long-term experimental research, American doctor of pedagogical sciences and neuropsychologist Angeline Lillard conducted a neurobiological analysis of the Montessori environment, concluding that: 'A systematic and predictable orderly environment plays a decisive role in inhibiting impulsive actions (inhibitory control), strengthening working memory, and shaping cognitive flexibility in the child's brain' [1, p. 142]. The aesthetic appeal of the environment and the precise placement of each object foster spatial reasoning and the ability to execute sequential logical operations from an early age.”

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In Montessori classrooms, practical life exercises (such as dusting, pouring water, buttoning, and sorting grains) serve as the foundation for cognitive development. Through these movements, the child establishes control over their physical body and conceptualizes motor kinetics. The theoretical and scientific basis of these processes is comprehensively elucidated by the famous neuropsychologist Alexander Luria's theory of the functional blocks of the brain. In his research, Luria scientifically demonstrated that fine motor skills and goal-directed movements of the fingers differentially stimulate the sensorimotor and speech (Broca's and Wernicke's) areas of the cerebral cortex, stating: “The kinematic precision of hand movements is not merely a physical skill, but the neurobiological bedrock of higher psychological functions, particularly internal speech and logical reasoning” [2, p. 84]. Montessori practical activities extend the child's attention span (concentration) and reinforce volitional qualities at a neurophysiological level [3, p. 52].

Sensory education is a structured system through which a child analyzes the properties of external objects (such as size, color, shape, and mass) using their sensory organs (visual, tactile, auditory, olfactory, and gustatory). As Maria Montessori emphasized: “The senses are the gateways of the mind to the external world. Sensory materials transform chaotic impressions into systematic concepts and analytical intelligence” [3, p. 118]. This approach aligns perfectly with both classical and contemporary psychological theories of child intellectual development. In his theory of cognitive development, the Swiss psychologist Jean Piaget delineates the period from ages 2 to 7 as the “preoperational stage of intelligence,” indicating that all of the child's cognitive processes are constructed upon the physical manipulation of objects [4, p. 88]. The German educator Friedrich Fröbel also acknowledged that sensory perception is primary in the formation of logical thinking [5, p. 63]. Montessori sensory education provides the child with a neuropedagogical bridge to transition from the abstract to the concrete, and from sensory perception to logical cognition.

In the Montessori methodology, language and speech development are facilitated through the child’s tactile (tracing sandpaper letters with fingers) and visual perception. Rather than merely memorizing letters as in traditional schooling, the child constructs their motor image. From a neurolinguistic perspective, this process is deeply intertwined with Noam Chomsky’s theories of innate universal grammar and the Language Acquisition Device (LAD). According to Chomsky, the human brain possesses a biological program for language acquisition that must be activated by external stimuli during a specific ontogenetic period [6, p. 41]. During the linguistic sensitive period between the ages of 2.5 and 6 identified by Maria Montessori, neuroplasticity reaches its peak. In the process of working with sensory materials, tactile, visual, and acoustic neuronal connections are synthesized in parallel, allowing the child to acquire writing and reading skills naturally and without cognitive strain [7, p. 122].

In conclusion, structuring the cognitive development of preschool children based on neuropedagogical principles is a fundamental task of modern preschool education theory. Scientific and theoretical analyses indicate that the Maria Montessori methodology possesses a profound neurobiological basis that fully aligns with the developmental laws of a child’s cerebral cortex and cognitive functions. The system’s order, practical life exercises, and sensory materials stimulate prefrontal cortex activity, integrate fine motor skills with speech centers, and facilitate the acquisition of abstract concepts through visual-tactile means. Applying these neuropedagogical aspects of the Montessori method within the Republic of Uzbekistan's preschool education system, particularly when implementing State requirements, yields high pedagogical efficiency in nurturing a well-rounded generation that is creative, capable of independent thought, and possesses a high intellectual quotient.

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