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NEUROSCIENCE IN EARLY CHILDHOOD EDUCATION

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Abstract

This study aims to analyze the application of neuroscience principles in early childhood as a basis for developing effective and holistic learning strategies. This research employs a literature review (library research) method by examining various scientific literatures related to child brain development, cognitive stimulation, and neuroscience-based learning approaches in the context of early childhood education. The results show that the application of neuroscience principles, such as the importance of environmental stimulation rich in positive experiences, emotional engagement in the learning process, and respect for the uniqueness of each child's brain, contributes significantly to optimizing children's learning potential. Neuroscience-based learning strategies encourage teachers to create activities that stimulate various areas of the brain through play, sensory exploration, and meaningful creative activities. Thus, an understanding of neuroscience can serve as an important foundation for early childhood educators in designing adaptive, enjoyable, and developmentally appropriate learning experiences.

Keywords: *neuroscience; brain stimulation; learning strategies; early childhood education.*

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INTRODUCTION

Neuroscience is the study of the nervous system, particularly the brain, and its relationship to human behavior, emotions, and learning processes. In the context of early childhood education, neuroscience provides important insights into how a child's brain develops, when the golden age occurs, and how appropriate stimulation can maximize a child's developmental potential.[1]

Early childhood (0-6 years) is a crucial period for brain development. Research shows that approximately 80% of human brain development occurs before the age of six. During this period, a child's brain undergoes rapid growth, marked by the formation of billions of nerve cells (neurons) and connections between neurons (synapses). These synaptic connections can be strengthened or weakened depending on the quality of stimulation the child receives.

Neuroscience is the field of science that studies how the brain works, how the brain processes information, and how the results influence behavior and a person's learning process.[2] Meanwhile, according to some, neuroscience is the science that connects brain structure, brain function, and its implications in daily life, particularly in the teaching and learning process. From both theories, it can be concluded that neuroscience is a multidisciplinary science that studies the human brain and nervous system in terms of its structure and function.[3]

Neuroscience in education, often called Educational Neuroscience, is a scientific field that combines findings from neuroscience, psychology, and pedagogy (educational science) to understand how the brain learns and to develop more effective teaching strategies.[4]

RESEARCH METHOD

The method used in this research is a literature study with a qualitative approach.[5] The library research method is a data collection and analysis method that focuses on literature sources such as books, journals, and documents, rather than direct field interaction. Essentially, the researcher reads, examines, and analyzes various literature sources to understand a phenomenon, build theory, or answer research questions, with stages including searching, organizing, recording, and writing reports using sources in the form of documents related to the topic of discussion.[6] The collected data on

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[1] Indah Permata et al., "Pengaruh Kecerdasan Intelektual Dan Kecerdasan Emosional Dalam Perspektif Neurosains Di Dunia Pendidikan," *Journal of Information System and Management (JISMA)* 3, no. 2 (2024): 60–64, https://doi.org/https://doi.org/10.4444/jisma.v3i2.959.

[2] David A Sousa, *How the Brain Learns*, 4th ed. (California: Corwin Press, 2011), 24, https://doi.org/https://doi.org/10.4135/9781071855324.

[3] Aminul Wathon, "Neurosains Dalam Pendidikan," *JURNAL LENTERA : Kajian Keagamaan, Keilmuan Dan Teknologi* 13, no. 2 (2015): 136–45.

[4] Muhibbin Syah, *Psikologi Pendidikan Dengan Pendekatan Baru* (Bandung: Remaja Rosdakarya, 2013), 32.

[5] HM Diah, *Penelitian Kualitatif Dalam Penerapan* (Pekanbaru: Depdiknas Pusat Bahasa, 2005), 25.

[6] Sugiyono, *Metodologi Penelitian Kualitatif.* (Jakarta: Alvabeta, 2015), 300.

Neuroscience in Early Childhood is analyzed using various perspectives. The data obtained is qualitative data without formulas, numbers, or calculations.[7]

RESULTS AND DISCUSSION

Neuroscience is a field of science that studies the nervous system, especially the brain, and its relationship to human behavior, emotions, and learning processes. In the context of early childhood education, neuroscience provides scientific understanding regarding how a child's brain works and how stimulation can affect their cognitive and emotional development.

Research shows that approximately 80% of human brain development occurs before the age of six. During this period, a child's brain undergoes rapid growth through the formation of nerve cells (neurons) and connections between neurons (synapses). These synaptic connections can be strengthened or weakened depending on the quality of environmental stimulation the child receives.[8]

The results of the literature analysis indicate that neuroscience-based learning emphasizes the importance of: [1] Environmental stimulation rich in positive experiences; [2] Emotional engagement in the learning process; and [3] Respect for the uniqueness of each child's brain. Teachers as learning facilitators play an important role in creating learning activities that stimulate various brain areas. Recommended activities include play, sensory exploration, fine and gross motor activities, and creative activities that are meaningful for children.

This approach aligns with Sousa's view that the learning process is optimized when there is strong emotional involvement and enjoyable learning experiences.[9] Similarly, Wathon asserts that neuroscience connects brain structure, brain function, and its implications in daily learning.[10] Through neuroscience-based learning, teachers can help children optimize their brain function in a fun and developmentally appropriate way. Thus, neuroscience can become a scientific foundation in designing early childhood education curricula that are humanistic, holistic, and oriented towards child brain development.

Early Childhood Brain Development

A child's brain development is dynamic and highly influenced by experience. Two important concepts in developmental neuroscience are neuroplasticity (the brain's ability to change and adapt) and critical periods (sensitive periods when the brain is highly receptive to specific stimulation).

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[7] Lexy J. Moelong, *Metode Penelitian Kualitatif* (Bandung: Remaja Rosdakarya, 2002), 2.

[8] Novita Sari et al., "Pemahaman Pada Neurosains Pada Pendidikan Islam Dan Hubungannya Dengan Perkembangan Karakter," *Indonesian Journal of Multidisciplinary on Social and Technology* 2, no. 2 (2024): 28–33, https://doi.org/https://doi.org/10.31004/ijmst.v2i2.301.

[9] Sousa, *How the Brain Learns*, 24–25.

[10] Wathon, "Neurosains Dalam Pendidikan."

a. 0-1 year (infant): the brain develops through sensorimotor experience, emotional bonding with parents, and basic stimulation such as touch, sound, and facial expressions;
b. 1-3 years (early toddler): rapid development occurs in language skills, fine motor skills, and early emotional regulation. Children begin to imitate behavior, speak, and show high curiosity;
c. 3-6 years (preschool): development expands to cognitive aspects, creativity, memory, social skills, and self-control. In this phase, formal education can begin using a play-based approach.

Early childhood brain development is one of the most important aspects of human growth. Early childhood, particularly the age range of 0-6 years, is often called the golden age, because approximately 80% of human brain development occurs during this period. During this time, nerve cells (neurons) and connections between neurons (synapses) form very rapidly, so a child's brain has an extraordinary capacity to absorb information from their environment. This brain development process is not only determined by genetic factors but is also greatly influenced by the quality of experience, stimulation, and environment provided to the child from an early age.[11]

During infancy (0-1 year), the brain develops rapidly through sensorimotor experience involving the senses, body movement, and emotional bonding with parents or primary caregivers. Eye contact, touch, hugs, and positive responses from adults are crucial in strengthening emotional bonds while forming the foundation for brain development. Entering the age of 1-3 years, children show significant development in language and motor skills. In this phase, children begin to learn to speak, imitate words, remember vocabulary, and express basic emotions. Additionally, early social skills begin to form through interaction with their environment.

During preschool (3-6 years), brain development becomes more complex, especially in the prefrontal cortex, which functions in self-control, simple decision-making, and problem-solving. Children in this phase are more creative, imaginative, and begin to be capable of symbolic thinking and using language more complexly. Social-emotional development also matures further, marked by the ability to play together, understand simple rules, and begin learning to empathize with others.

The process of early childhood brain development is heavily influenced by several main factors, including genetics, environment, stimulation, nutrition, health, and warm emotional relationships with parents and educators. Important principles underlying child brain development include the concept of neuroplasticity or the brain's ability to change according to experience, critical periods that mark sensitive times for receiving

[11] Jack P. Shonkoff and Deborah A. Phillips, *From Neurons to Neighborhoods: The Science of Early Childhood Development* (Washington: National Academies Press, 2000), 89, https://doi.org/10.17226/9824.

specific stimulation such as language, and the principle of 'use it or lose it', which indicates that brain connections that are not used will weaken or disappear.[12]

The implications of early childhood brain development for children's education are significant. Education in the early stages of life should be based on meaningful play, rich multisensory experiences, and opportunities for children to explore. A warm, safe, and loving learning environment is essential for children to feel comfortable and able to develop their brain potential optimally. Thus, understanding early childhood brain development becomes an important foundation for educators and parents in providing appropriate stimulation for children to grow into intelligent, creative, and characterful individuals.

Neuroscience Principles in Early Childhood Education

Early childhood education essentially aims to optimize all aspects of a child's development through appropriate, enjoyable, and age-appropriate stimulation. In the context of neuroscience, there are several important principles that form the basis for designing early childhood education that aligns with how the brain works and develops. These principles stem from the understanding that early childhood is both a critical period and a golden age for brain development, heavily influenced by the quality of a child's early experiences.

The first principle is that children learn most effectively through play. Play is not only a means of entertainment but is a biological activity that stimulates neural connections and strengthens brain networks. Through play, children gain multisensory experiences, train motor skills, develop language, and build social and emotional skills. The second principle is the importance of experiences involving various senses. Children more easily understand new concepts when learning involves sight, hearing, touch, movement, and even smell. For example, children are not only taught colors verbally but are also invited to see, touch, and use colored objects in daily activities.[13]

The third principle is that secure and warm emotional bonds are crucial for a child's brain development. Positive interactions with parents and educators will build a sense of security essential for socio-emotional brain development. Children who feel loved, cared for, and valued will be more able to learn and manage emotions. The fourth principle is the balance between stimulation, rest, nutrition, and physical activity. A child's brain needs energy and a healthy body condition to function optimally; therefore, balanced nutrition, adequate sleep, and opportunities for active movement become integral parts of neuroscience-based education.

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[12] Mesya Adhelia, Isfauzi Hadi Nugroho, and Veny Iswantiningtyas, "Speech Delay Pada Anak Usia Dini Ditinjau Dari Perspektif Neurosains," in *Prosiding SEMDIKJAR (Seminar Nasional Pendidikan Dan Pembelajaran)*, 2025, 921–28, https://doi.org/https://doi.org/10.29407/qy8bvp53.

[13] Lilif Muallifatul, Khorida Filasofa, and Asya Ainul Fitri, "Pembelajaran Berbasis Neurosains Dalam Perspektif Guru Raudlatul Athfal," *Jurnal Pelita OAUD* 8, no. 2 (2024): 454–61, https://doi.org/https://doi.org/10.33222/pelitapaud.v8i2.3769.

The next principle is that the learning environment must be rich in positive experiences. Children need varied interactions with people, objects, and situations around them to expand their brain networks. An environment full of violence, stress, or lacking stimulation can hinder neural brain growth, while a warm, safe, and stimulating environment will encourage the optimal development of a child's potential.[14] Furthermore, neuroscience also emphasizes that every child has unique brain development, so education should not demand uniformity but provide space for children's individuality. Thus, the principles of neuroscience in early childhood education affirm the importance of an approach oriented towards play, multisensory experience, positive emotional bonds, physical-psychological balance, and a rich and supportive learning environment. The application of these principles is expected to optimize child brain development during the golden age, forming a strong foundation for future learning success and personality development.[15]

Examples of learning activities in Early Childhood Education based on neuroscience principles. The following will be explained in detail:

a. The Basic Principle of Learning Through Play

The principle of learning through play is a fundamental approach in early childhood education based on child development theory and supported by neuroscience findings. Play is viewed not only as a recreational or entertainment activity but as a natural means for children to explore the environment, develop cognitive, social, emotional, language, and motor skills. Through play, children are given the opportunity to learn actively, enjoyably, and in accordance with their brain development stage.[16]

From a neuroscience perspective, play activities are proven to stimulate the formation and strengthening of synaptic connections in a child's brain. When children engage in play, various parts of the brain work simultaneously: the sensory brain receives stimulation from the environment, the motor brain regulates body movement, the limbic system manages emotions and motivation, while the prefrontal cortex is involved in decision-making and problem-solving. Thus, play functions as a comprehensive learning medium because it integrates thinking, feeling, and action processes.

This principle also aligns with the views of developmental experts, such as Piaget, who emphasized that play is a vehicle for children to adapt to their environment, and Vygotsky, who asserted that play plays an important role in shaping higher cognitive functions through social interaction. Therefore, in the context of early childhood education, play must be designed as a meaningful,

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[14] Nur Hidayah et al., *Psikologi Pendidikan* (Malang: Universitas Negeri Malang, 2017), 78.

[15] Adhelia, Nugroho, and Iswantiningtyas, "Speech Delay Pada Anak Usia Dini Ditinjau Dari Perspektif Neurosains."

[16] Raihana, "Motivasi Belajar," in *Psikologi Belajar*, ed. Fransiska Anggraini (Tangerang: WADE Publisher, 2022), 97.

structured, and stimulation-rich learning experience, not merely a time-filling activity.

Pedagogically, applying the principle of learning through play implies that educators must be able to provide a conducive, safe, and experience-rich learning environment and facilitate play that supports children's holistic development. By applying this principle, early childhood education can proceed according to the natural development of children while providing a strong foundation for cognitive, social, emotional, and spiritual growth in the future.[17]

Forms of play in the principle of learning through play are implementations of early childhood education. The principle of learning through play can be realized in various forms of games designed according to children's developmental stages. These forms of play are not just time-filling activities but learning vehicles rich in stimulation for children's cognitive, socio-emotional, language, and motor development. The following are several forms of play that can be applied:

1) Sensorimotor Play

   This form of play generally appears in infancy to toddlerhood, where children gain learning experience through their senses and body movements. Examples include playing with sand, water, playdough, or simple games like dropping and picking up objects. These activities stimulate the sensory and motor brain and strengthen neural connections through multisensory experience.

2) Constructive Play

   At this stage, children use objects or tools to build something, such as stacking blocks, assembling Lego, or drawing. Through constructive play, children learn to plan, solve problems, and practice hand-eye coordination. From a neuroscience perspective, this activity stimulates the prefrontal cortex, which plays a role in executive functions, planning, and creativity.

3) Dramatic Play (Role-Playing)

   ole-playing, such as pretending to be a doctor, teacher, or family member, is a form of symbolic play common in preschool children. This activity trains language skills, imagination, empathy, and social skills. The child's brain is stimulated in the areas regulating language (Broca's and Wernicke's areas) and the limbic system related to emotional understanding.

[17] Retisfa Khairanis and Muhammad Aldi, "Pendidikan Islam Berbasis Neuroedukasi: Strategi Pembelajaran Al-Qur'an," *Jurnal Pengembangan Dan Pengabdian Masyarakat Multikultural* 3, no. 1 (2025): 41–50, https://doi.org/https://doi.org/10.57152/batik.v3i1.2001.

4) Social Play (Cooperative)

This form of play occurs when children interact with peers, for example, playing group games, simple board games, or traditional games. Social play helps children understand rules, practice cooperation, and control emotions. From a neuroscience perspective, this develops brain areas related to emotional regulation and interpersonal relationships.

5) Creative and Artistic Play

Activities such as singing, dancing, painting, or playing music not only provide pleasure but also involve the whole brain. Art and creativity are proven to strengthen memory, increase concentration, and foster children's self-confidence.[18]

In conclusion, regarding the principle of learning through play in early childhood from a neuroscience perspective, by providing a variety of these forms of play, educators can ensure that the principle of learning through play is optimally implemented. The chosen games should be meaningful, age-appropriate, and rich in stimulation, so that children not only enjoy playing but also gain learning experiences that strengthen brain development and form long-term life skills.

b. The Principle of Multisensory Experience

The principle of multisensory experience is an important approach in early childhood education that emphasizes the simultaneous involvement of various child senses in the learning process. Multisensory includes stimulation through sight, hearing, touch, smell, and taste, which together provide a more meaningful learning experience. For early childhood, learning cannot be separated from sensorimotor activity because, during this period, the brain develops very rapidly, and synaptic connections are strengthened through experiences involving many senses.

From a neuroscience perspective, learning that involves multisensory can activate more brain areas simultaneously. For example, when children learn to recognize colors through finger painting, the visual brain (occipital lobe) receives color information, the motor brain regulates hand movements, while the limbic system plays a role in building positive emotions. This cross-area activation strengthens neural networks, making information easier to understand, remember, and use in other contexts.[19]

The application of the multisensory principle also aligns with child development theory, which states that the richer the sensory experiences a child

[18] Muallifatul, Filasofa, and Fitri, "Pembelajaran Berbasis Neurosains Dalam Perspektif Guru Raudlatul Athfal."

[19] Salamah Eka Susanti, "Pembelajaran Anak Usia Dini Dalam Kajian Neurosains," *TRILOGI: Jurnal Ilmu Teknologi, Kesehatan, Dan Humaniora* 2, no. 1 (2021): 53–60.

obtains, the better their cognitive, language, socio-emotional, and motor development. Children learn not only through verbal explanations but also through concrete experiences involving interaction with objects, the environment, and other people.

Pedagogically, early childhood educators are required to design learning activities that provide various sensory experiences. Examples of applying this principle include: Sight (visual) – recognizing shapes and colors through pictures, cards, or real objects. Hearing (auditory) – learning through songs, music, or listening to stories. Touch (tactile) – playing with sand, clay, or natural materials. Smell (olfactory) – distinguishing the scents of flowers, fruits, or spices. Taste (gustatory) – recognizing sweet, salty, sour tastes through healthy foods. Thus, the principle of multisensory experience not only enriches the child's learning process but also helps strengthen brain connections and optimize holistic developmental potential. A multisensory learning environment will create a fun, challenging, and developmentally appropriate learning atmosphere for early childhood.[20]

Examples of multisensory learning activities for early childhood will be explained in the form of the following table:

Table 1.
Multisensory Learning

Stimulated Sense	Example Activity	Brain Aspects Stimulated
Sight (Visual)	Observing pictures, colors, shapes, or assembling picture puzzles	Activates the occipital lobe (visual cortex), strengthens visual memory, and trains concentration
Hearing (Auditory)	Singing together, listening to stories, playing simple musical instruments	Activates the temporal lobe (auditory cortex), develops phonological awareness and rhythmic skills
Touch (Tactile)	Playing with sand, playdough, or finger painting	Stimulates somatosensory sensors, strengthens hand-eye coordination, and creativity
Smell (Olfactory)	Recognizing the scents of flowers, spices, fruits, or essential oils	Activates the limbic system (emotion & memory), links learning experiences with feelings
Taste (Gustatory)	Recognizing sweet, salty, sour, bitter tastes through fruits or healthy foods	Stimulates the gustatory cortex, builds cognitive skills (distinguishing tastes), and enriches real experience

From the table above, it can be concluded that the more human senses involved simultaneously, the stronger the synaptic connections formed in the child's brain. Multisensory activities should be packaged in a fun, safe atmosphere

[20] Mary Helen Immordino-Yang and Antonio Damasio, "We Feel, Therefore We Learn: The Relevance of Affective and Social Neuroscience to Education," *Mind, Brain, and Education* 1, no. 1 (2007): 3–10, https://doi.org/https://doi.org/10.1111/j.1751-228X.2007.00004.x.

appropriate for the early childhood developmental stage. This principle supports holistic learning because children learn not only through words but through direct experiences that engage their senses.

c. *The Principle of Secure Emotional Bonding*

The principle of secure emotional bonding is an important foundation in the implementation of early childhood education. Children in the early developmental stages greatly need positive emotional attachment (attachment) with parents, educators, and their surrounding environment. Secure emotional bonds are formed when children feel accepted, loved, protected, and valued, thus fostering self-confidence and readiness to face learning experiences.[21]

From a neuroscience perspective, warm and affectionate emotional relationships have a significant impact on child brain development. When children receive attention and positive attachment, their bodies release oxytocin and endorphin hormones that create feelings of comfort, happiness, and safety. This condition directly lowers stress hormone (cortisol) levels, allowing the child's brain to absorb information and form new synaptic connections more optimally. Conversely, children who experience emotional pressure or lack affection are at risk of experiencing hindrances in their cognitive, social, and emotional development.

Secure emotional bonding also aligns with the attachment theory proposed by John Bowlby, which asserts that the first emotional relationship between a child and their primary caregiver forms the basis for personality development, social skills, and the way a child views the world. Children with secure attachments tend to be more independent, able to control emotions, and have better adaptive abilities. In early childhood education practice, the application of this principle can be realized in various ways, including giving warm greetings, hugs, or positive touch when children arrive at school; creating a classroom environment full of affection, respect, and free from fear; listening and responding to children's feelings with empathy; providing consistent routines so children feel safe and can predict their environment; and building open communication between educators and parents to strengthen children's emotional bonds at home and at school.[22]

With secure emotional bonding, children will feel comfortable exploring their environment, dare to try new things, and be able to build healthy social

[21] Siti Nurfadlah Fadlah, Ahmad Muttaqin, and Iis Maesaroh, "Integrasi Neurosains Dalam Pendidikan: Studi Literatur Tentang Proses Belajar Berbasis Otak," *PAIDAGOGIA: Jurnal Pengajaran Dan Pendidikan* 1, no. 1 (2024): 36–42, https://ejournal.sumulepubid.com/index.php/paidagogia/article/view/10.

[22] Anugrah Ainul Yakin, "Hibridisasi Pendidikan Islam Dan Neurosains: Implementasi Paradigma Integrasi Keilmuan Dalam Pendidikan Islam," *MA'ALIM: Jurnal Pendidikan Islam* 6, no. 2 (2025): 153–67.

interactions. This becomes a very important foundation for the child's future cognitive, language, motor, and life skills development.

d. The Principle of Balanced Stimulation, Rest, and Nutrition

The principle of balanced stimulation, rest, and nutrition is one of the main pillars in early childhood education directly related to brain development and children's holistic health. In early childhood, a child's brain develops very rapidly, thus requiring appropriate stimulation, sufficient rest time, and balanced nutritional intake so that growth and learning processes can occur optimally.

From a neuroscience perspective, stimulation given to children in the form of learning experiences, social interactions, or play activities plays an important role in forming new synaptic connections. However, excessive stimulation without accompanying rest can cause mental and physical fatigue, ultimately hindering the learning process. Rest, especially quality sleep, is essential because during sleep, the brain consolidates memory, strengthens neural connections, and reorganizes emotional functions.[23]

In addition to stimulation and rest, nutritional factors also play a fundamental role. Balanced nutrition, especially intake of protein, vitamins, minerals, and essential fatty acids (such as DHA and omega-3), supports brain cell growth, enhances cognitive function, and maintains children's physical health. Nutritional deficiencies in early childhood have proven negative impacts on brain development, concentration, and learning abilities.

Pedagogically, applying this principle requires educators and parents to regulate children's activity patterns in a balanced way. Some steps that can be taken include providing fun and developmentally appropriate play and learning activities; ensuring sufficient rest or naptime at school and at home; scheduling daily activities that are not too packed so children do not experience fatigue; providing balanced nutritious foods, such as fruits, vegetables, milk, and protein sources, while limiting instant or high-sugar foods; and teaching healthy lifestyle habits, such as drinking water, light exercise, and maintaining cleanliness.

By applying a balance between stimulation, rest, and nutrition, early childhood will grow in healthy physical and psychological conditions, have sufficient energy to learn, and have a brain ready to receive new information. This simultaneously becomes an important foundation for the development of intelligence, character, and children’s life skills in the future.

e. The Principle of an Environment Rich in Positive Experiences

The principle of an environment rich in positive experiences emphasizes the importance of providing a learning atmosphere that is safe, enjoyable, and full of exploration opportunities for early childhood. The environment referred to is not

[23] Naily et al., “Neuroscience Learning in Early Childhood Education,” *English Language Teaching Journal* 4, no. 1 (2024): 32–38, https://ejournal.alqolam.ac.id/index.php/eltj/article/view/1279.

limited to physical spaces like classrooms or playgrounds but also includes the psychological, social, and emotional climate that supports children's overall development.

From a neuroscience perspective, an environment rich in positive experiences directly plays a role in shaping and strengthening synaptic connections in a child's brain. Pleasant experiences stimulate the release of dopamine and endorphin hormones that increase learning motivation and create feelings of happiness. Conversely, an environment full of pressure, fear, or punishment can increase excessive stress hormones (cortisol), thereby hindering children's cognitive function, memory, and emotional regulation.[24]

An environment rich in positive experiences is characterized by the presence of diverse activities appropriate to developmental stages, the use of varied learning media, and warm and supportive social interactions. Children are given opportunities to try, experiment, ask questions, and discover new things through direct experience. This not only develops cognitive aspects but also fosters children's social, emotional, language, and motor skills.

In early childhood education practice, this principle can be realized through several steps, including providing a safe, clean, colorful, and organized learning space; offering exploration-based learning activities, such as gardening, water play, or simple experiments; using diverse media and teaching aids, both from artificial and natural materials; presenting a friendly, affectionate classroom atmosphere free from verbal and physical violence; and giving children opportunities to express themselves, make simple decisions, and show creativity.[25]

Thus, an environment rich in positive experiences not only serves as a learning tool but also functions as a protective factor supporting children's psychological well-being. Children who grow up in a positive environment tend to be more confident, daring to explore, and have high learning motivation. This becomes important capital for their readiness to face developmental challenges in the subsequent stages.

f. The Principle of Respecting Each Child's Uniqueness

The principle of respecting each child's uniqueness emphasizes that every child is a different individual, with unique potential, interests, learning styles, backgrounds, and developmental pace. Early childhood education must not be uniform or demand that children follow a single standard but must be able to

[24] Wasul Nuri Wasul and Suyadi, "Peran Emosi Positif Dalam Pembelajaran Pendidikan Islam Perspektif Neurosains," *El-Darisa: Jurnal Pendidikan Agama Islam* 4, no. 1 (2025): 31–45, https://ejournal.staihwduri.ac.id/index.php/eldarisa/article/view/93.

[25] Usha Goswami, "Neuroscience and Education : From Research to Practice ?," *Nature Reviews Neuroscience* 7 (2006): 406–413, https://doi.org/10.1038/nrn1907.

accommodate this diversity so that each child can develop optimally according to their capacity.

From a neuroscience perspective, each child's brain develops with different patterns of synaptic connections, influenced by genetic factors, experience, and environment. Therefore, effective learning strategies must consider these individual variations. Children given the opportunity to learn according to their interests and strengths will experience strengthening in specific neural pathways, thus maximizing the development of innate potential while fostering self-confidence and intrinsic motivation.

This principle also aligns with humanistic views in education, which place children as learning subjects, not objects. By respecting children's uniqueness, educators provide space for them to express themselves, explore according to their interests, and find learning methods most suitable for themselves. This not only supports academic development but also shapes a healthy, independent, and competitive personality.[26]

In early childhood education practice, the principle of respecting each child's uniqueness can be realized in various ways, including giving children the opportunity to choose activities according to their interests through play areas (reading corner, art corner, science corner, etc.); designing diverse and flexible learning strategies to accommodate visual, auditory, kinesthetic, or combined learning styles; avoiding comparisons between children, instead focusing on each individual's developmental achievements; appreciating children's efforts, not just final results; and providing an inclusive environment friendly to children with special needs.

By applying this principle, children will feel accepted, valued, and motivated to develop their potential. This will create a strong foundation for the development of personality, independence, and children's social skills in the future.

Implications of Neuroscience in Early Childhood Education

Neuroscience as the science that studies brain structure, function, and development provides important contributions in formulating early childhood education practices. Knowledge about how the brain develops, how synapses form and strengthen, and how early experiences shape children's thinking patterns and behavior becomes the scientific basis for early childhood education teachers in designing effective, meaningful, and developmentally appropriate learning. Several important implications of neuroscience in early childhood education include:

[26] Muhammad Andreansyah Hidayatulloh and Muhammad Zaki Maulana, "Kurikulum Akhlak Neuro-Islamik Di Era Post-Truth: Pendekatan Neurosains Dan Nilai Tarbiyah," *Jurnal Dinamika Pendidikan* 11, no. 4 (2025): 77–86, https://journal.nuspublications.or.id/jdp/article/view/126.

a. Importance of the Golden Age: Neuroscience affirms that 80% of brain development occurs at ages 0-6. This period is a critical period where appropriate stimulation will strengthen synaptic connections, while lack of stimulation can cause children's developmental potential to be suboptimal. Therefore, early childhood education must be designed to provide rich, positive, and diverse learning experiences;
b. Learning Through Play: Brain research shows that children learn more effectively when they are happy and actively involved. Play is not merely entertainment but the main means of forming brain connections related to language, emotion, motor skills, and social skills. This affirms that play is a highly important pedagogical strategy in early childhood education;
c. The Role of Emotion in Learning: Neuroscience finds that emotions play a major role in the learning process. Children who feel safe, loved, and valued will have brain conditions more ready to receive information. Conversely, stress and fear can increase cortisol hormones that actually hinder cognitive development. Therefore, secure emotional bonds between children and teachers and the learning environment become key;
d. Multisensory Experience: A child's brain develops better when learning involves many senses (visual, auditory, tactile, olfactory, and gustatory). Multisensory activities strengthen synaptic pathways because they involve various brain areas simultaneously. The implication for early childhood education is the importance of presenting concrete, diverse, and direct experience-based learning activities.
e. Balanced Stimulation, Rest, and Nutrition: Neuroscience shows that learning cannot be separated from physical health. Rest (especially sleep) is needed for memory consolidation, while adequate nutrition supports brain cell growth and cognitive function. Early childhood education must pay attention to the balance of learning activities, rest time, and adequate nutritional intake.
f. Positive and Stimulation-Rich Environment: A safe, loving environment that provides many exploration opportunities will increase children's intrinsic motivation and stimulate the release of dopamine hormones that support learning enthusiasm. The implication for teachers is to create a conducive, pressure-free classroom rich in positive experiences.
g. Respecting Children's Uniqueness: Neuroscience proves that each child's brain develops with different patterns. No two children have exactly the same synaptic pathways. Therefore, early childhood education must be inclusive, differentiated, and respect each child's pace and learning style.[27]

[27] Immordino-Yang and Damasio, "We Feel, Therefore We Learn: The Relevance of Affective and Social Neuroscience to Education."

It can be concluded that the implications of neuroscience in early childhood education affirm that the learning process must be child-centered, enjoyable, safe, and rich in experience. Teachers not only act as instructors but also as facilitators capable of presenting a learning environment that aligns with how children's brains work. With this understanding, early childhood education can function optimally in developing all aspects of a child's potential, be it cognitive, language, socio-emotional, motor, or spiritual.

CONCLUSION

Neuroscience is very important in early childhood education. Understanding how a child's brain works helps educators create effective, enjoyable, and developmentally appropriate learning strategies. A stimulative, safe, and positive learning environment plays an important role in strengthening neural connections in a child's brain, thereby supporting optimal development in cognitive, social, and emotional aspects.

Furthermore, neuroscience provides a scientific basis for educators to understand individual differences among children and adapt the most appropriate learning methods for each student. This study recommends that further research be conducted empirically in early childhood education settings to test the effectiveness of neuroscience-based learning strategies in real contexts. Thus, theory and practice in early childhood education can complement each other to produce a generation that is intellectually and emotionally intelligent.

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