An investigation of montessori and reggio emilia play environments in terms of brain-based learning

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ABSTRACT

This study aims to comparatively examine the play-based learning environments of the Montessori and Reggio Emilia approaches within the framework of brain-based learning principles. The study is structured as a multiple case study within a qualitative research design. Data were collected through structured observations, semi-structured teacher interviews, and document analysis. Observations were carried out in both schools' play environments for three consecutive days, and teacher interviews were conducted with four educators. The collected data were analyzed using thematic analysis and categorized under six main themes: features of the physical environment, teacher roles, children's behaviors, use of materials, decision-making processes, and alignment with brain-based learning principles. The findings reveal that the Montessori approach offers a structured and simple learning environment emphasizing individual attention, self-regulation, and intrinsic motivation. In contrast, the Reggio Emilia approach emphasizes social interaction, creative expression, and democratic participation through a flexible and aesthetically oriented environment. It was concluded that both approaches support different aspects of brain-based learning; Montessori particularly addresses mechanisms such as attention, repetition, and self-control, while Reggio Emilia activates neural systems related to social learning, emotional security, and creativity. In this context, the study provides theoretical and practical contributions to teacher training, environmental design, and curriculum development.

Keywords: *Brain-based learning, early childhood education, Montessori approach, play environment design, Reggio Emilia approach, nature.*

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Highlights of this paper

- This study compares Montessori and Reggio Emilia play environments based on brain-based learning principles.
- Findings show that Montessori emphasizes structured learning and self-regulation, while Reggio Emilia supports creativity, social interaction, and emotional development.
- The study offers guidance for improving early childhood learning environments aligned with brain-based learning.

1. INTRODUCTION

Early childhood is one of the most rapid, flexible, and environmentally sensitive periods of human development (Shonkoff & Phillips, 2000). Experiences during this stage lay the foundation for an individual's cognitive, emotional, and social structures. One of the most effective ways to support children's development is through educational practices centered on play, their natural mode of learning. Play offers a multifaceted learning environment in which children interact with their surroundings, explore social roles, express emotions, and develop problem-solving skills (Whitebread, 2018). Especially for ages 3–6, play-based learning supports executive functions, attention, memory, and self-regulation (Diamond, 2013). Therefore, play should be seen not only as an enjoyable activity but also as a scientifically grounded tool that fosters child development.

Recently, brain-based learning approaches have gained prominence in the field of education, providing a biological perspective to instructional design by grounding the learning process in neuroscience (Caine & Caine, 1997; Jensen, 2008). According to this approach, learning is not solely a mental process but rather a multilayered phenomenon shaped by the holistic interaction of physiological, emotional, and environmental factors. Brain-based learning principles advocate that individuals learn best in meaningful contexts and emotionally secure, enriched environments (Jensen, 2008). It is thus asserted that stimuli engaging the senses have a direct impact on children's brain development. Especially in play environments, visual, auditory, and tactile materials can promote neuroplasticity and increase the permanence of learning (Willis, 2007).

In line with these principles, it is emphasized that educational settings should be designed not solely for information transmission but to stimulate all developmental domains, spark the desire for exploration, and support the internalization of learning. At this point, alternative early childhood education approaches such as Montessori and Reggio Emilia stand out for their child-centered structures. The Montessori method provides a learning environment that respects individual differences and is supported by sensory materials. This approach allows the child to direct their own learning process, thereby enhancing self-regulation and decision-making skills (Lillard, 2019). The Reggio Emilia approach considers the child as a social being and integrates the learning process with social interaction, creativity, and aesthetic sensitivity. In this approach, the environment is regarded as the "third teacher," meaning that the physical design of learning spaces is viewed as a pedagogical factor directly influencing child development (Manera, 2022).

Both approaches emphasize environmental arrangements, child-centered practices, and play-based interactions that align with the principles of brain-based learning. In the Montessori approach, the use of orderly and simple materials that foster children's attention and concentration skills is emphasized, while Reggio Emilia environments are based more on aesthetic designs that stimulate the child's imagination and on group-based projects (Edwards, Gandini, & Forman, 2012). In both approaches, play is regarded as the child's natural mode of learning, and learning environments are structured to maximize the developmental benefits of this play (Lillard, 2019).

In this context, not only the pedagogical function of play environments but also how these environments are designed has become a subject of scientific inquiry. Play areas designed in accordance with brain-based learning

principles can foster children's positive attitudes toward learning, help them feel emotionally secure, and support their developmental growth (Jensen, 2008; Sousa, 2011). Recent studies have revealed that play-based and child-centered practices positively influence cognitive flexibility, executive functions, and socio-emotional development (Diamond, 2013; Immordino-Yang, Darling-Hammond, & Krone, 2019).

However, in Turkey, comprehensive and comparative studies on how Montessori and Reggio Emilia practices are designed within the framework of brain-based learning remain limited. In the literature, this gap becomes evident particularly in the lack of in-depth data on the extent to which early childhood education environments align with neuroscientific principles (Erkılıç, 2019; Tekerci & Balkıç, 2024). This deficiency constitutes an important area of research for both academic circles and educational practitioners.

Therefore, this study aims to examine the design of play environments in Montessori and Reggio Emilia approaches conceptually and practically in the light of brain-based learning principles. In this way, it will provide a scientifically grounded evaluation of how play-based pedagogical environments can be integrated with children's brain development. Accordingly, the following section will address the theoretical foundations of brain-based learning principles and their relationship with Montessori and Reggio Emilia approaches.

2. THEORETICAL FRAMEWORK

2.1. Core Principles of Brain-Based Learning

The brain-based learning approach argues that learning emerges from the holistic interaction of biological, psychological, and environmental factors (Caine & Caine, 1997). This perspective emphasizes that learning is not merely a cognitive process but is significantly influenced by one's emotional state, environmental conditions, social relationships, and motivation (Immordino-Yang & Damasio, 2007; Jensen, 2008).

According to Jensen (2008), the core principles of brain-based learning include emotional safety, holistic learning, environmental stimulation, meaningful connections, social interaction, repetition, and timing. These principles offer crucial insights for constructing learning environments that align with children's neurological development, particularly in early childhood.

Emotional safety refers to the learner feeling valued, secure, and accepted in the learning environment. When the brain perceives a threat, cortisol levels rise, and executive functions become inhibited, thus reducing learning potential (McEwen, 2012; Sousa, 2011). In a secure and supportive environment, the brain becomes more open to learning; cognitive processes such as attention, memory, and problem-solving become more efficient. In early childhood, trusting relationships with adults play a critical role in fostering positive attitudes toward learning.

Holistic learning refers to a developmental process that supports not only cognitive development but also social, emotional, and physical growth. The brain processes experiences holistically rather than in isolation; thus, learning should be enriched with real-life experiences and contextual relevance (Caine & Caine, 1997; Jensen, 2008). Multi-sensory experiences such as art, movement, play, and group interactions stimulate different regions of the brain simultaneously.

Environmental stimulation refers to the learning environment being rich in sensory stimuli and conducive to exploration. Elements such as color, light, sound, texture, organization, and natural materials contribute to focus, curiosity, and lasting learning (Jensen, 2008; Willis, 2007). Children explore their surroundings, particularly through sensory-based activities, which help strengthen synaptic connections.

In addition to these, meaningful learning and connection-making are also fundamental. Linking new knowledge with prior experiences facilitates comprehension and accelerates transition to long-term memory (Sousa, 2011). For

young children, learning environments enriched with concrete, visual, and sensory stimuli ease the process of making connections.

Lastly, social interaction is indispensable for brain-based learning. Through peer interaction, children develop social skills such as empathy, turn-taking, and cooperation. These processes activate mirror neuron systems and social brain networks, thereby providing neurobiological support for learning (Immordino-Yang, 2016; Rizzolatti & Craighero, 2004). Group play, collaborative problem-solving, and project-based activities foster this development.

In this regard, a brain-based educational environment should not merely focus on knowledge transmission but should also support the child's emotional safety, social bonds, sensory exploration, and meaningful learning processes. How these principles are concretized within alternative educational models such as Montessori and Reggio Emilia will be elaborated in the following sections.

2.2. Play and Environment Design in the Montessori Approach

The Montessori method is a pedagogical model structured around the individual pace, interests, and developmental levels of children, emphasizing active participation (Isaacs, 2012; Lillard, 2019). It fosters learning environments that support intrinsic motivation, allowing children to discover learning through direct experience (Loeffler, 1992; Montessori, 1967).

Montessori classrooms are meticulously designed to support children's physical, cognitive, and social development. The materials used are often functional tools derived from real life, each simplified to focus on a single concept or skill. These materials promote concentration, self-directed error correction, repetition, and self-assessment (Kramer, 1976; Lillard, 2019). Sensory development materials such as sound cylinders, color tablets, and tactile boxes enhance attention and perception through sensory stimulation (Standing, 1998).

This approach strongly aligns with brain-based learning principles. For instance, children's freedom to choose their own activities and manage their learning process supports emotional safety (Caine & Caine, 1997; Sousa, 2011). Additionally, the use of holistic materials in daily life activities, language, mathematics, and cultural areas activates multiple learning domains simultaneously (Hainstock, 1997; Lillard, 2019).

The structured environment in Montessori classrooms is particularly beneficial for the development of executive functions, such as planning, sequencing, attention control, and impulse regulation. These functions are naturally cultivated through independent work and repetition-based learning (Diamond & Lee, 2011; Lillard et al., 2017). Research shows that children in Montessori education exhibit higher performance in self-regulation, attention span, and social skills compared to their peers (Rathunde & Csikszentmihalyi, 2005).

These findings indicate that the Montessori approach is grounded not only pedagogically but also neurodevelopmentally. Its carefully structured environment, repetition, and free-choice principles directly support the development of the prefrontal cortex, fostering positive learning attitudes and cognitive resilience (Jensen, 2008; Willis, 2007).

Thus, Montessori pedagogy is a powerful model that operationalizes brain-based learning principles through learning environment design and play-based interactions where children take active roles. This structure supports not only conceptual development but also the neurobiological processes shaped through real-life experiences.

2.3. The Role of the Environment in the Reggio Emilia Approach: "The Third Teacher"

The Reggio Emilia approach is a participatory early childhood education model that emerged in the Reggio Emilia region of Italy after World War II under the leadership of Loris Malaguzzi. It views the child as an active learner and meaning-maker (Edwards et al., 2012). At its core, it lies the understanding that the child is a being who

expresses themselves through a hundred languages, engages in exploration and inquiry, and interacts socially. Reggio pedagogy defines the learning process as a triangle between the child, the teacher, and the physical environment, each of which plays an active role in learning (Rinaldi, 2006). In this framework, the environment is not merely a space where learning takes place but is positioned as an active "third teacher" that interacts with the child and shapes the learning process (Gandini, 2012).

Reggio Emilia classrooms are carefully designed multisensory, aesthetic, and collaborative environments that support children's processes of exploration, investigation, and expression. These environments prominently feature areas illuminated with natural light, panels displaying children's work, documentation boards for learning processes, and ateliers (material workshops) (Vecchi, 2010). The materials used are typically open-ended, reusable, and designed to stimulate children's creativity (Strong-Wilson & Ellis, 2007). In this regard, Reggio Emilia environments are enriched not only pedagogically but also in terms of sensory, aesthetic, and social interaction dimensions.

This approach aligns directly with brain-based learning principles. Emotional security is fostered in Reggio Emilia classrooms by valuing children's ideas, making their thinking visible through documentation, and by adults taking their learning seriously (Edwards et al., 2012; Rinaldi, 2006).

Environmental stimulation is supported through physical settings that evoke aesthetic sensitivity using light, color, texture, natural materials, and artistic arrangements (Gandini, 2012; Rathunde & Csikszentmihalyi, 2005).

Holistic learning is provided through experiences involving nature, art, science, group work, and long-term projects that address multiple developmental domains of the child (Edwards et al., 2012).

The open-ended projects and collaborative learning processes offered in Reggio environments also support the development of children's social-cognitive skills. Empathy, social perspective-taking, cooperation, and collaborative problem-solving are behaviors that are explicitly encouraged in Reggio pedagogy (Rinaldi, 2006; Vygotsky, 1978). These skills are closely linked to neuroscientific processes such as the mirror neuron system, emotional resonance, and Theory of Mind. In particular, the mirror neuron system plays a fundamental role in understanding others' actions and intentions and forms the neurobiological basis of social learning (Rizzolatti & Craighero, 2004). From this perspective, the Reggio Emilia approach has a strong foundation not only pedagogically but also in terms of social brain development.

In conclusion, Reggio Emilia pedagogy largely overlaps with brain-based learning principles through physical environments structured to support the child's social, emotional, and cognitive development. Positioning the environment as a "teacher" enables the child to take an active and creative role in the learning process, allowing learning to be integrated with both neurodevelopmental and pedagogical foundations.

2.4. The Relationship Between the Approaches and Developmental Processes

The Montessori and Reggio Emilia approaches show strong parallels with brain-based learning principles on both pedagogical and neurodevelopmental levels. Both approaches emphasize the child's active participation, meaningful interactions, and learning through play, considering the learning environment not only as a physical space but also as a component that supports cognitive and emotional development (Edwards et al., 2012; Lillard, 2019).

In particular, the Montessori approach stands out in supporting the development of executive functions. Executive functions include high-level skills such as attention control, planning, problem-solving, self-regulation, and cognitive flexibility (Diamond, 2013). Individual workspaces, simplified materials, and opportunities for self-paced progress offered in Montessori classrooms directly contribute to the development of these functions (Lillard et al., 2017). Structured routines and repetition-based activities support children's attention span, impulse control, and task completion abilities.

In contrast, the Reggio Emilia approach is notable for its structure that supports social brain development, creativity, and emotional expression. In this approach, the environment is designed to enrich children's social interactions and develop social-cognitive skills such as empathy (Rinaldi, 2006). Open-ended materials, group projects, ateliers, and collaborative learning activities promote both social and emotional development. In this aspect, Reggio Emilia pedagogy aligns with social neuroscience processes such as the mirror neuron system, Theory of Mind, and emotional resonance (Immordino-Yang, 2016; Rizzolatti & Craighero, 2004).

While Montessori's use of simple and controlled materials enhances children's attention and self-regulation skills, Reggio Emilia's aesthetic sensitivity and multisensory environments improve sensory integration, creativity, and learning competence within a social context (Vecchi, 2010). Thus, both approaches offer powerful practices that support different dimensions of brain-based learning.

In conclusion, a comparative examination of the Montessori and Reggio Emilia approaches offers a holistic bridge between brain-based learning and pedagogical practices. While Montessori supports individual structuring and executive function development, Reggio Emilia emphasizes social interaction and creative expression. Based on this theoretical foundation, the next section will address how these approaches are integrated into the research process through the methodological framework.

3. METHOD

3.1. Research Design

This study is based on the multiple case study design, one of the qualitative research methods. Multiple case studies allow for an in-depth examination of more than one case with similar structures within their own contexts (Yin, 2018). Since the aim of the study is to conduct a comparative analysis of play environments within the Montessori and Reggio Emilia approaches in the context of brain-based learning principles, each approach was considered a distinct "case." Accordingly, the study aimed to describe each case in detail and then analyze common themes through a comparative lens (Stake, 2005).

3.2. Participants and Research Setting

The study group consisted of two kindergartens located in different regions of Turkey, each maintaining a distinct institutional identity. One of the schools is a private kindergarten in a metropolitan city that adopts the Montessori approach, while the other is an independent kindergarten in a medium-sized city inspired by the Reggio Emilia philosophy. Both institutions serve children aged 3–6, and in this study, two classrooms within this age range were selected as observation units.

The participants included four teachers (two from each school). The Montessori school teachers had 5 and 8 years of professional experience, while the Reggio Emilia school teachers had 6 and 10 years of experience. All teachers held undergraduate degrees in early childhood education.

No direct data were collected from the children themselves. Instead, the focus was placed on the educational environments and teacher practices, and observations were carried out as passive observers in the natural setting. For ethical reasons, the actual names of the institutions are not disclosed; however, their educational approaches, structural characteristics, and regional contexts have been described to ensure transparency.

3.3. Data Collection Tools

Observation forms, semi-structured interview forms, and document analysis were used during the data collection process.

- Observation Forms: Structured observation forms were used to systematically record the physical environment of the Montessori and Reggio Emilia classrooms, the layout of play areas, the variety of materials, the behaviors exhibited by children during play, and teacher–child interactions. Observations were conducted over three days in each classroom during morning hours, lasting between 60 and 90 minutes.
- Semi-Structured Interviews: Individual interviews were conducted with two teachers from each school. The interview form covered teachers' perspectives on the design of play environments, their responses to children's play, their awareness of brain-based learning principles, and their reflections on their own pedagogical practices. Interviews were audio-recorded and transcribed by the researcher.
- Document Analysis: Visual materials, classroom layout plans, and institutional brochures obtained from the schools were used as supporting data.

3.4. Data Collection Period

In this study, observations were conducted during morning hours (between 08:45 and 10:30) in both schools. This timing was chosen for several pedagogical and practical reasons.

- Neuroscientific research indicates that executive functions such as attention, planning, and self-regulation in early childhood operate more actively in the morning hours (Diamond & Lee, 2011; Jensen, 2008).
- In preschool programs, cognitively demanding activities are typically scheduled in the morning, while the afternoon is reserved for more relaxed and less intensive activities. This scheduling ensures that the observed behaviors are directly related to learning processes.
- Considering that children are generally more energetic, focused, and cooperative during the early hours of the day, morning observations yield more reliable and representative data.
- To maintain classroom routines, the schools requested that the data collection process take place in the morning.

Thus, the timing of observations was determined in alignment with both scientific findings on child development and the practical conditions of the field.

3.5. Data Analysis

The qualitative data collected were analyzed using descriptive analysis (Yıldırım & Şimşek, 2018). In the descriptive analysis process, observation and interview forms were first examined separately; then, the data from Montessori and Reggio Emilia classrooms were thematically categorized within their own contexts. The analysis was guided by predetermined themes based on brain-based learning principles, including emotional security, environmental stimulation, holistic learning, and the development of executive functions.

In addition, photographs and documents from the classrooms were used as visual data to support the analysis. These visual materials enriched the observation notes and helped visualize the findings.

3.6. Validity and Reliability

To enhance the internal validity of the study, data triangulation was employed. The use of observation, interviews, and document analysis allowed for a multifaceted examination of the data. Interview transcripts were

returned to participants for feedback (member checking). Furthermore, the researcher maintained detailed field notes during the observation and analysis processes for each school to ensure the integrity of the data sources.

For reliability, inter-coder consistency was checked by two independent coders during the data analysis, and a coder agreement of over 85% was achieved (Miles & Huberman, 1994).

3.7. Ethical Statement

Informed voluntary consent was obtained from all participants involved in the study. To ensure confidentiality and privacy, all data were anonymized, and personal information was concealed and used solely for scientific purposes. Throughout the research process, the rights and well-being of the participants were carefully protected.

4. FINDINGS

The data obtained in this study were analyzed using a thematic coding approach in line with the descriptive analysis process. The themes generated from observations, interviews, and document analyses provide a multidimensional picture of children's behavioral patterns in play environments, the roles of teachers, physical environment arrangements, and the use of materials. The findings were structured under six main themes: (1) characteristics of the physical environment, (2) the teacher's role and guidance approach, (3) children's behaviors (such as focus, sharing, error correction, collaboration), (4) alignment with brain-based learning principles, (5) materials used in play environments, and (6) decision-making and social interaction. Each theme was comparatively analyzed within the frameworks of Montessori and Reggio Emilia approaches and was interpreted with direct quotations.

4.1. Physical Environment and Material Organization

This theme examines the physical arrangement of Montessori and Reggio Emilia classrooms, the quality of materials used, and the accessibility of these environments to children. The data revealed that the way a classroom is organized directly influences children's attention, independence, and level of interaction.

4.1.1. Findings from the Montessori Classroom

In the Montessori classroom, observations showed that materials were arranged in fixed locations, natural lighting was prioritized, and every item was placed at a height accessible to children. Children returned the materials after use, which helped maintain classroom order. For example, one observation note stated:

"09:30 – It was observed that materials were regularly returned to their places."

Such repeated behaviors contribute to the development of self-discipline and an awareness of order among children. Materials were typically singular and wooden. According to the document analysis, the emphasis was not on quantity but on selective variety. Functionality was prioritized over visual aesthetics. Materials were not labeled, but were each designed to support specific cognitive or sensory skills.

4.1.2. Findings from the Reggio Emilia Classroom

In the Reggio Emilia classroom, an open-plan, flexible, and interaction-oriented layout was observed. Instead of fixed corners, the classroom had project-based areas and art centers known as *ateliers*. One observation note stated:

"09:00 – Children started a group activity at a table composed of natural materials."

This arrangement fostered cooperation and social interaction among children. According to document analysis, the classroom walls displayed panels documenting children's projects, developmental progress, and verbal

expressions. These panels not only conveyed information but also made the learning process visible, transforming the classroom into a dynamic learning environment.

The materials were open-ended and often made from natural or recycled resources. The use of aesthetic materials such as light tables, stones, fabric pieces, and glass objects was observed. These materials encouraged children's imagination and symbolic expression. Table 1 presents a concise comparison of the Montessori and Reggio Emilia environments regarding physical layout, material use, and learning purposes.

Table 1. Comparative evaluation table.

Criterion	Montessori approach	Reggio Emilia approach
Physical arrangement	Fixed and suited for individual work	Flexible and interaction-oriented
Purpose of Environment	Fosters self-regulation and independence	Encourages social interaction and creativity
Use of Materials	Functional, singular, natural materials	Open-ended, aesthetic, and recyclable materials
Classroom layout	Low shelves, clearly defined areas	Open spaces, adaptable according to projects
Aesthetic sensitivity	Functionality prioritized	Visual aesthetics and design emphasized
Learning environment	Prepared environment for individual experiences	Environment as an active "third teacher"

4.1.3. Comparative Evaluation

Montessori classrooms feature a more fixed and functional layout aimed at individual work, while Reggio Emilia classrooms are more flexible, interaction-based, and aesthetically driven. In Montessori, the organization of materials supports self-regulation and independence; in Reggio Emilia, the environment enhances social interaction and creative expression. In both approaches, the physical environment is considered a cornerstone of learning, though the targeted developmental skills differ.

4.2. Teacher Role and Guidance Style

This theme analyzes the roles of Montessori and Reggio Emilia teachers within the classroom, their methods of guiding children, and their approaches to intervention. The data reveal that rather than directly instructing children, teachers act as facilitators of the learning process, adopting different guidance strategies aligned with their respective pedagogical philosophies.

4.2.1. The Role of Montessori Teachers

Montessori teachers generally act as observers and guides. Observation data indicated that teachers did not directly interfere with children's use of materials but provided guidance only when necessary. For example:

"09:50 – The teacher only provided guidance when needed; the environment was very quiet."

Interview data showed that teachers allowed children the freedom to make their own choices and only offered support when challenges arose. One teacher stated.

"I'm mostly in an observing role, but I guide when needed. I leave space for the child's own exploration." (m1)

This approach is intended to support children's individual learning processes and the development of self-regulation skills.

4.2.2. The Role of Reggio Emilia Teachers

Reggio Emilia teachers play a mediating role, encouraging children to generate ideas, reflect, and communicate within the group. Observation data showed that teachers participated in the learning process more through guiding questions than through direct instruction.

"09:50 – The teacher supported the children's inquiries by asking guiding questions."

In the interviews, teachers explained.

"Rather than directing, I participate by asking questions or showing interest. I might ask, 'What does this stone remind you of?' to encourage their thinking." (r2)

This reflects a teacher profile that promotes active participation, inquiry-based thinking, and open dialogue. Table 2 presents a comparative overview of the teacher roles and guidance styles in Montessori and Reggio Emilia classrooms.

Table 2. Teacher role and guidance style.

Criterion	Montessori approach	Reggio Emilia approach
Teacher's position	In the background, observer	Active observer and facilitator
Style of Guidance	Avoids direct intervention; guides when necessary	Guides through questions and shared engagement.
Involvement in Learning	Supports individual exploration	Facilitates social interaction and group processes.
Teacher silence	Emphasizes silence and individual work	Guides within social interaction
Educational role	Not a knowledge transmitter; supports learning in the background	Not a knowledge transmitter; actively manages the process

4.2.3. Comparative Evaluation

Montessori teachers typically remain in the background and avoid intervening in the learning process, while Reggio Emilia teachers participate more actively as observers and questioners. In Montessori, the teacher supports silence and individual discovery; in Reggio Emilia, the teacher facilitates social interaction and creative processes. In both approaches, the teacher is not a traditional transmitter of knowledge but a child-centered guide.

4.3. Children's Behaviors and Developmental Indicators

This theme analyzes children's attention spans, use of materials, social interactions, and self-regulation skills based on observation and interview data. Developmental indicators were examined through the behaviors exhibited by children during play in Montessori and Reggio Emilia environments.

4.3.1. Observed Behaviors in the Montessori Environment

In Montessori classrooms, individual focus and self-regulation skills are prominent. Observational data indicated that children maintained attention for extended periods and independently monitored their own errors. For example:

"09:10 – A child maintained focus for 15 minutes while working with color tablets."

"10:00 – A child performed error control independently."

These observations suggest the development of self-discipline. Children demonstrated responsibility in using and returning materials without teacher intervention. Behaviors such as waiting for turns, sharing, and taking individual initiative were noteworthy. These findings highlight Montessori pedagogy's strong contribution to individual development domains such as independence, attention, and patience.

4.3.2. Observed Behaviors in the Reggio Emilia Environment

In the Reggio Emilia setting, children's social interaction and creative thinking processes are more pronounced. Observations showed that children actively participated in group work, clearly expressed their ideas, and developed collaborative decision-making skills. For example:

"09:45 – Children used a majority vote to make a decision about the project."

"09:20 – While one child was expressing an idea, others listened attentively."

These examples reveal patterns of active listening and cooperative communication. Children often gathered around a theme or material to produce a collective outcome. In atelier environments, they engaged in creative activities that reflected their ideas and shared their learning experiences through documentation panels. These observations provide important indicators of socio-interpersonal development and creative expression. Table 3 presents a comparative summary of children's behaviors and developmental indicators observed in Montessori and Reggio Emilia environments.

Table 3. Children's behaviors and developmental indicators.

Criterion	Montessori approach	Reggio Emilia approach
Focus area	Individual attention and self-regulation	Social participation and group interaction
Concept of discipline	Individual inner discipline	Democratic participation and social order
Developmental goals	Independence and personal responsibility	Creativity and collaborative decision-making
Learning style	Experiential, independent learning	Interactive and collaborative learning
Role of the Child	Self-directed individual	Researcher as part of the community

4.3.3. Comparative Evaluation

In Montessori environments, children's behaviors are shaped primarily by individual attention, self-regulation, and independence, while in Reggio Emilia environments, they are shaped by social participation, group dynamics, and creative production. While Montessori pedagogy emphasizes the development of internal discipline, the Reggio Emilia approach focuses on social learning and democratic participation processes. Both approaches acknowledge the child as an active subject, though the direction of that subjectivity varies.

4.4. Alignment with Brain-Based Learning Principles

This theme examines how the Montessori and Reggio Emilia approaches align with brain-based learning principles. Based on the framework developed by Caine and Caine (1991), the extent to which the environments incorporate elements such as emotional safety, meaningful repetition, social learning, and sensitivity to individual differences was analyzed.

4.4.1. Indicators of Alignment in the Montessori Approach

Observations and teacher interviews in Montessori classrooms show consistency with brain-based learning, particularly in terms of emotional safety, structured repetition, respect for individual differences, and movement-based learning. For example:

"A child performed error control independently."

"It was observed that materials were regularly returned to their places."

These indicate that learning was supported through self-regulation and repeated experiences. In teacher interviews, it was noted that repetition with materials enhances focus and self-regulation, and that children are able to make independent decisions within an emotionally secure environment:

"Especially working repeatedly with the same material improves children's focus and self-regulation… My intervention is usually limited to observation; I guide only when needed." (m1)

"Children are completely free in choosing their materials; this enhances their ability to make independent decisions." (m2)

This structure aligns with attention systems in the brain, automatic repetition mechanisms, and learning models grounded in emotional security.

4.4.2. Indicators of Alignment in the Reggio Emilia Approach

The Reggio Emilia approach aligns strongly with brain-based principles such as social learning, holistic learning through meaningful projects, emotional engagement, and curiosity-provoking environmental design. Teacher interviews revealed statements such as:

"I ask questions to encourage the child's thinking." (r2)

"They made decisions about the project together." (r1)

These statements reflect support for social brain development and interaction-based learning. The classroom environment is equipped with open-ended materials that stimulate curiosity, and children are encouraged to plan their own projects. The environment supports multisensory engagement. In this respect, the Reggio Emilia approach is consistent with principles of sensorimotor integration, social interaction, and visual-spatial development. Table 4 presents a comparative overview of how the Montessori and Reggio Emilia approaches align with key brain-based learning principles.

Table 4. Alignment with brain-based learning principles.

Criterion	Montessori Approach	Reggio Emilia Approach
Learning approach	Individual learning, structured repetition	Social learning, project-based structure
Brain-based focus	Attention, automation, intrinsic motivation	Social brain, emotional interaction, curiosity
Environmental features	Simple, repetitive, suited to individual experiences.	Rich, interactive, aesthetic, and creative
Teacher role	Observer and guide when necessary	Questioning facilitator of the process
Cognitive goals	Focus, self-regulation, personal responsibility	Expressive skills, creativity, collaboration

4.4.3. Comparative Evaluation

The Montessori approach supports aspects of brain-based learning such as attention, automation, and intrinsic motivation through individualized learning and structured repetition. The Reggio Emilia approach stimulates the brain's social and creative networks by promoting learning through interaction, curiosity, and emotional engagement. While both approaches structure environments that support brain development, they differ in the cognitive areas they emphasize.

4.5. Materials Used in Play Environments

This theme analyzes the variety, quality, modes of interaction, and developmental contributions of materials used in the play environments of Montessori and Reggio Emilia classrooms.

4.5.1. Use of Materials in the Montessori Environment

Materials used in Montessori classrooms were observed to be natural, simple, and functional. Each material is structured to develop a specific cognitive or sensory skill. The purposeful design of each item helps children focus

their attention and carry out error control independently. Document analysis revealed that selective variety is prioritized over quantity, and functionality is valued more than aesthetics. For example, an observation note stated:

"A child worked alone with sound cylinders and placed the material back in its place."

This illustrates how the material supports the development of self-awareness, focus, and self-regulation.

4.5.2. Use of Materials in the Reggio Emilia Environment

In Reggio Emilia classrooms, materials are open-ended and often composed of natural or recycled items. They are diverse in form and aim to enhance children's imagination and multiple forms of expression. Items such as light tables, colorful stones, fabric scraps, and natural objects were observed to support creative expression. Teacher interviews indicated that children derive various meanings from the same material and that materials support collective rather than individual production. In this approach, materials are not just tools but are seen as active components of learning that interact with the child. Table 5 presents a comparative summary of the materials used in Montessori and Reggio Emilia play environments.

Table 5. Materials used in play environments.

Criterion	Montessori approach	Reggio Emilia approach
Type of material	Natural, simple, structured	Natural, open-ended, recycled
Purpose of material	Targets specific skills, emphasizes functionality	Fosters creative expression, multiple meanings
Usage style	Individual, rule-based	Group-based, freely used
Developmental contribution	Attention, self-regulation, individual responsibility	Imagination, creativity, collective production
Interaction with material	The child adapts to the material	The material interacts with the child

4.5.3. Comparative Evaluation

As seen in the table 5, the Montessori approach positions materials as structured tools for individual learning, encouraging children to focus deeply on specific skills. The Reggio Emilia approach, on the other hand, positions materials as multifaceted tools for expression, supporting learning through social, artistic, and cognitive interactions. In both approaches, materials are central to education; however, their pedagogical applications serve different learning goals.

4.6. Decision-Making and Social Interaction

This theme focuses on children's decision-making skills, group interactions, and social communication patterns during play. It particularly evaluates how children express ideas, discuss, and make decisions among themselves under teacher guidance.

4.6.1. Decision-Making and Social Interaction in the Montessori Approach

As individual learning is central in the Montessori classroom, decision-making typically occurs independently. Observational data indicated that children selected materials on their own, returned them after use, and waited for turns or shared as needed. These behaviors support the development of personal responsibility and intrinsic motivation. However, group interaction was limited. Social engagement was mostly observed during material sharing or use of common areas.

4.6.2. Decision-Making and Social Interaction in the Reggio Emilia Approach

Since the Reggio Emilia approach centers on group-based project work, decision-making processes involve intensive social interaction among children. Observations noted the following.

"Children used majority vote to make a decision about the project."

"While one child explained their idea, the others listened attentively."

These findings demonstrate the development of active listening, idea generation, and democratic participation skills. Teacher interviews supported these observations, with teachers stating that they guide children through decision-making processes and emphasize peer collaboration:

"They usually work together, forming groups around a project or idea. I value collaborative decision-making highly. They discuss and decide on everything from the color to the shape of a project." (r1)

"Instead of directing, I participate by asking questions or showing interest. I ask things like 'What does this stone remind you of?' to stimulate their thinking... I encourage them to consult their peers. Peer support is very powerful sometimes, one child's idea sparks another's insight." (r2)

Table 6 presents a comparative overview of children's decision-making and social interaction patterns in Montessori and Reggio Emilia environments.

Table 6. Decision-making and social interaction.

Criterion	Montessori approach	Reggio Emilia approach
Decision-making style	Individual choice and responsibility	Group discussion and majority voting
Social interaction	Limited, mostly during material sharing	Intense, project- and group-based interaction
Communication style	Silence and individual focus	Verbal expression, idea exchange, active listening
Teacher role	Observer supports individual process	Facilitator and questioner in the process
Developmental goal	Intrinsic motivation, personal responsibility	Social responsibility, democratic participation

4.6.3. Comparative Evaluation

The Montessori approach views decision-making as a domain of personal responsibility, while the Reggio Emilia approach allows children to develop decision-making skills in a social context. In Montessori environments, children quietly make and implement their own choices. In contrast, in Reggio Emilia classrooms, children discuss and make collective decisions as a group. This structure supports Reggio Emilia's developmental goals of democratic participation, community building, and social responsibility. Both approaches recognize the child as a decision-making agent, yet they implement this principle in different ways.

5. DISCUSSION

Within the scope of this study, the ways in which the Montessori and Reggio Emilia approaches support child development in play-based learning environments were examined comparatively through the framework of brain-based learning theory. The findings indicate that while both approaches position the child as an active learner, they align with brain-based learning principles in different ways regarding teacher roles, use of materials, forms of social interaction, and environmental arrangements. The Montessori approach stands out particularly with its emphasis on individual repetition, error control, and intrinsically motivated learning processes. In the observed classrooms, children developed sustained attention through quiet and orderly use of materials, which in turn supported their self-regulation skills. This finding is consistent with Jensen's (2008) view that learning can be reinforced through repetition-based activities in a low-stress and high-trust environment. Furthermore, the literature provides evidence

that Montessori methods support learning at the neurobiological level. For example, Politi (2023) highlights that Montessori's pedagogical approach is closely linked to processes of self-regulation, sensory experience, and synaptic consolidation. Similarly, a longitudinal study found that Montessori education positively influences individuals' well-being, sense of social trust, and feelings of engagement in adulthood (Angeline S Lillard et al., 2017).

In contrast, the Reggio Emilia approach strongly emphasizes the social and emotional dimensions of brain-based learning. The active participation of children in decision-making, idea-sharing, and creative production processes is not only aligned with Vygotsky (1978) sociocultural development theory but also supports the model of (Caine & Caine, 1991), who argue that learning occurs most powerfully within a social context. Teachers in Reggio settings engage in the process by asking questions that stimulate children's curiosity, thereby fostering the development of executive functions and activating higher-order cognitive processes in the frontal cortex (Immordino-Yang & Damasio, 2007). Additionally, the structuring of the environment as a "third teacher" in Reggio Emilia makes it possible for children to actively engage with materials and environmental arrangements, thereby enhancing emotional commitment to learning (Robson & Mastrangelo, 2017). The use of open-ended, multisensory materials further allows children to develop diverse modes of expression, consistent with Gardner's (1993) theory of multiple intelligences. Indeed, in a comparative analysis of Montessori, Waldorf, and Reggio Emilia approaches, Aljabreen (2020) also reported that Reggio places greater emphasis on artistic expression, creativity, and social interaction, whereas Montessori is distinguished by its focus on individual concentration and material repetition.

In this context, the unique contribution of the present study lies in its direct comparison of the Montessori and Reggio Emilia approaches with reference to brain-based learning principles using observational data. In the literature, the individualized and repetition-based features of Montessori (Angeline S Lillard et al., 2017; Politi, 2023) and the social and creative aspects of Reggio Emilia (Aljabreen, 2020; Robson & Mastrangelo, 2017) have been discussed separately. However, this study examines both approaches within the same context, concretizing their differences and similarities through play-based learning processes. Moreover, being conducted in Turkey, it provides insight into the characteristics of local applications and thus contributes to the international literature. The findings demonstrate that brain-based learning can be supported in educational environments through different pathways via individual focus and self-regulation in Montessori, and through social interaction and democratic participation in Reggio Emilia.

6. CONCLUSION

This study holistically revealed how the Montessori and Reggio Emilia approaches structure play environments in early childhood education, how these environments support children's development, and how teacher roles are shaped within these contexts. Although both approaches place the child at the center as an active learner, they differ in how they align with brain-based learning principles in terms of pedagogical priorities and environmental design.

Montessori classrooms aim to develop individual attention, self-regulation, and intrinsic motivation through a structured and simple physical environment. The error-checking nature of the materials allows children to reinforce their learning through synaptic repetition. In this sense, Montessori pedagogy supports the brain-based principles of individual meaning-making, repetition, and intrinsic motivation, as proposed by Caine and Caine (1991).

The Reggio Emilia approach, by contrast, enriches the physical environment with social interaction and aesthetic experiences to stimulate children's emotional, social, and creative development. Children's active participation in project-based group work, involvement in decision-making processes, and interactions with open-ended materials support the affective and social dimensions of learning. This supports the assertion by Immordino-Yang and Damasio (2007) that emotion and social context play a critical role in brain-based learning processes.

Findings on teacher roles show that in Montessori settings, teachers act more as observers and guides, while in Reggio Emilia, they play a facilitative role, engaging in dialogue throughout the learning process. This finding also aligns with Vygotsky's (1978) theory that learning is a socially mediated process.

Overall, this study indicates that both approaches contribute to brain-based learning from different dimensions: Montessori pedagogy more effectively supports cognitive and self-regulatory systems, while Reggio Emilia pedagogy supports the social, emotional, and creative brain systems. These differences suggest that educators should make pedagogical decisions based on the developmental domains they aim to prioritize in learning environment design.

7. RECOMMENDATIONS

7.1. Brain-Based Approaches Should Be Integrated into Teacher Education Programs

Teacher training curricula should incorporate both theoretical and practical content on how brain-based learning principles can be applied especially in play-based environments. This would help teachers identify and support children's needs in attention, memory, social interaction, and emotional development.

7.2. Flexibility and Functionality Should Be Balanced in Physical Environment Design

A hybrid learning environment could be created by combining the structured simplicity of Montessori classrooms with the aesthetic flexibility of Reggio Emilia settings, thereby supporting both individual learning and social collaboration.

7.3. Material Use Should Be Enriched in Terms of Multiple Intelligences and Sensory Engagement

Considering both pedagogical philosophies, play areas should include a combination of structured and open-ended materials to support children's individual skills and creative potential.

7.4. Children's Participation in Decision-Making Should Be Strengthened

To foster children's social participation skills, practices such as group decision-making, collaborative projects, and idea exchange, as seen in the Reggio Emilia approach, should be supported. These practices are important for the development of the prefrontal cortex and executive functions.

7.5. Teacher Roles Should Balance Observation and Facilitation

Combining the observational stance of Montessori with the active facilitation seen in Reggio Emilia would support both independent learning and socially guided interaction.

7.6. Brain-Based Learning Principles Should Be Emphasized in Education Policy

Preschool curricula and implementation guides should promote flexible, holistic approaches grounded in brain-based learning principles that address the developmental needs of the child.

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