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Cognitive Development in Rural Children Age 6-8 Years: Integrating Piaget's Theory and Neurocognitive Perspective

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ABSTRACT

Cognitive development among children aged 6–8 in rural areas is often constrained by limited environmental stimulation, yet few studies integrate cognitive, socio-ecological, and neurocognitive perspectives to explain these disparities. This study aims to analyze how these dimensions interact in shaping children's cognitive development in rural Indonesia. This research employed an exploratory qualitative case study involving nine children aged 6–8 years, nine parents, and two teachers in a rural area of Banjarnegara, Central Java. Data were collected through semi-structured interviews, observations, and document analysis, and analyzed thematically using integrated coding based on Piagetian, Bronfenbrenner's bioecological, and neurocognitive frameworks. The findings reveal three distinct developmental profiles based on levels of family stimulation. Children with high stimulation demonstrated stable concrete operational thinking, including conservation, classification, and sustained attention. Those with moderate stimulation showed transitional cognitive patterns with emerging but inconsistent logical reasoning. In contrast, children with low stimulation remained in the preoperational stage, characterized by perceptual reasoning, weak working memory, and limited self-regulation. The results indicate that cognitive development is influenced by the interaction between family support (microsystem), home–school continuity (mesosystem), and executive function capacity. The study highlights that cognitive development in rural children is not solely age-dependent but shaped by the synergy of environmental stimulation and neurocognitive processes. Strengthening family–school collaboration and providing context-based cognitive stimulation are essential to support optimal development in rural educational settings.

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1. INTRODUCTION

Cognitive development among children aged 6–8 years in rural contexts remains a critical issue in contemporary education, particularly in developing countries where disparities in access to learning resources persist. Children in this age group are especially vulnerable to delays in foundational thinking skills due to limited environmental stimulation, socio-economic constraints, and restricted access to quality educational support. Global evidence indicates that children in developing regions demonstrate lower levels of literacy and basic cognitive skills compared to their counterparts in more developed contexts (Bilad et al., 2024). Such disparities are further exacerbated in rural areas, where structural inequalities—including limited infrastructure, low parental literacy, and minimal exposure to technology—reduce opportunities for meaningful cognitive engagement (Betancur et al., 2024). Consequently, cognitive development cannot be understood solely as a function of biological maturation but must be examined in relation to the broader socio-cultural and educational environments in which children grow (Aranbarri et al., 2023).

The age range of 6–8 years represents a pivotal transitional phase in cognitive development, as children begin to shift from intuitive to logical thinking. According to Piagetian theory, children at this stage gradually enter the concrete operational phase, characterized by the ability to understand conservation, classification, and reversibility (Miller, 2020; Muqaddaskhan, 2024). Cognitive growth occurs through processes of assimilation and accommodation, which enable children to integrate new experiences into existing mental structures and adjust these structures when encountering novel information (Anderson, 2022; Jadidah et al., 2023). Importantly, these processes are highly dependent on interaction with the environment. In rural settings, everyday activities such as farming, household responsibilities, and community engagement provide concrete experiences that can support cognitive development (Glorius et al., 2021). Additionally, communal cultural values, including cooperation and shared responsibility, may reinforce social cognition and practical reasoning (Nirwansyah et al., 2022). However, without structured cognitive stimulation, these experiences may not fully support the development of higher-order thinking skills.

Beyond individual cognitive processes, children's development is deeply embedded within social and ecological systems. Bronfenbrenner's bioecological theory emphasizes that development occurs through interactions within nested environmental systems, particularly the microsystem (family and school) and mesosystem (interactions between these settings) (Navarro & Tudge, 2025). In the context of rural education, the quality of family–school relationships plays a crucial role in sustaining cognitive stimulation and supporting children's learning trajectories. Schools provide structured opportunities for logical reasoning through guided instruction and experiential learning (Sofni Indah Arifa Lubis et al., 2024), while families reinforce these experiences through daily interactions and emotional support. Studies have shown that consistent collaboration between home and school environments enhances children's cognitive and socio-emotional outcomes (Sun & Wang, 2022). In rural contexts, where formal educational resources may be limited, this ecological synergy becomes even more essential. Moreover, culturally embedded practices, such as nature-based learning and communal engagement, can enrich children's cognitive experiences when aligned with educational goals (Hayat et al., 2024; Zakharova et al., 2022).

In recent years, the neurocognitive perspective has provided further insight into the mechanisms underlying cognitive development. During middle childhood, the prefrontal cortex undergoes rapid development, supporting executive functions such as attention, working memory, and self-regulation (Solichah et al., 2025). These functions are critical for problem-solving, logical reasoning, and academic readiness. Environmental stimulation plays a significant role in shaping neural development; enriched learning environments strengthen neural connectivity and cognitive performance, whereas deprived or monotonous environments may hinder brain development (Horowitz-Kraus et al., 2024; Di Marco et al., 2021). This perspective highlights that disparities in environmental stimulation—particularly between urban and rural contexts—may lead to differences in both cognitive outcomes and underlying neural processes. Therefore, understanding cognitive development requires an integrative approach that considers both environmental and biological factors.

Despite extensive research on child development, existing studies often examine cognitive, socio-ecological, and neurocognitive dimensions in isolation. For example, some studies focus primarily on Piagetian cognitive stages (Mauluddia & Solehuddin, 2023), while others emphasize parental influence or socio-economic factors (Hanifah et al., 2022). Neurocognitive research, on the other hand, frequently concentrates on executive function development in urban populations without adequately considering socio-cultural contexts (Freitas et al., 2022). This fragmentation limits the ability to understand how multiple factors interact to shape children's development, particularly in rural settings where contextual influences are highly pronounced. As a result, there remains a significant gap in empirical research that integrates these perspectives into a unified analytical framework.

Addressing this gap is particularly important in the Indonesian rural context, where variations in family support, educational access, and community resources may significantly influence developmental outcomes. Specifically, little is known about how differences in family stimulation and home–school interaction affect executive functions and the transition toward concrete operational thinking among rural children. Given that cognitive development is influenced by both environmental inputs and internal capacities, an integrative approach is needed to capture the complexity of these interactions.

Therefore, this study aims to analyze the cognitive development of children aged 6–8 years in rural Indonesia by integrating Piaget's cognitive developmental theory, Bronfenbrenner's bioecological framework, and neurocognitive perspectives. This study is guided by three research questions: (1) How do cognitive development patterns differ among children with varying levels of family stimulation? (2) How do family and school ecological systems interact to influence children's cognitive development? and (3) How do neurocognitive capacities—particularly attention, working memory, and self-regulation—mediate the relationship between environmental stimulation and cognitive developmental stages? By addressing these questions, this study seeks to provide a more comprehensive understanding of cognitive development in rural contexts and to contribute to the development of context-sensitive educational strategies that support children's learning and development.

2. METHODS

2.1 Research Design

This study employed a qualitative exploratory case study design to examine children's cognitive development within a specific rural socio-ecological context (Hollweck, 2015; Sugiyono, 2017; w John & J David, 2023). In this research, the case is defined as the pattern of cognitive development among children aged 6–8 years living in a rural community, as shaped by varying levels of family stimulation and their interaction with school and social environments. The case is not an individual child alone, but a bounded system consisting of children, families, and schools embedded within a rural ecological setting. An exploratory case study design was selected because cognitive development in rural Indonesian contexts remains underexplored, particularly when examined through an integrated framework combining Piagetian developmental stages, Bronfenbrenner's bioecological systems, and neurocognitive perspectives. This design enables an in-depth and holistic analysis of how biological maturation, concrete learning experiences, family interaction patterns, and socio-cultural environments jointly influence children's thinking processes. Rather than testing predefined hypotheses, the approach allows the identification of developmental patterns and mechanisms emerging from real-life contexts, which is particularly relevant for understanding cognitive development in under-resourced rural settings (Hollweck, 2015; Sugiyono, 2017; w John & J David, 2023).

2.2 Location, Subjects and Participants

The study was conducted in Banjarnegara Regency, Central Java, Indonesia, which was selected based on theoretical relevance rather than mere convenience. Banjarnegara represents a rural socio-ecological context characterized by dispersed settlements, an agriculture-based economy, strong communal social relations, and limited access to educational resources and learning technologies. These characteristics make Banjarnegara theoretically relevant for examining how children's cognitive development is shaped by concrete daily experiences, family-based learning practices, and social interactions—key elements emphasized in Piaget's, Bronfenbrenner's, and neurocognitive frameworks.

From a Piagetian perspective, Banjarnegara provides a context where children's learning is closely tied to direct manipulation of objects and real-life activities, such as helping parents with farming and household tasks. From a bioecological perspective, the region offers a clear illustration of how microsystem (family and school) and mesosystem (home–school interaction) processes operate within a rural cultural setting. From a neurocognitive standpoint, variations in environmental stimulation and parental involvement in this context allow examination of how executive functions such as attention, working memory, and self-regulation develop under differing levels of cognitive support.

The primary participants consisted of nine children aged 6–8 years, all girls, who were purposively selected based on three levels of family stimulation: high, moderate, and low. Each child was accompanied by one parent (n = 9) as a key informant to provide data on home-based stimulation and daily learning interactions. In addition, two classroom teachers were included to triangulate data related to children's cognitive behavior and learning experiences in the school environment.

Children classified as receiving high family stimulation experienced consistent parental involvement in learning activities such as reading, discussion, and guided problem-solving. Moderate-stimulation children received irregular educational support, often limited to basic supervision without systematic guidance. Low-stimulation children had minimal educational interaction at home, with limited exposure to structured cognitive activities. This variation enabled a comparative analysis within the bounded case, highlighting how differences in family stimulation interact with rural socio-ecological conditions to shape children's cognitive development.

2.3 Analysis, Validity, Credibility, and data Collecttion Techinques

Data were collected through semi-structured interviews, direct observation, and document analysis involving children, parents, and teachers. Interviews lasted approximately 15–30 minutes for children and 30–40 minutes for parents and teachers and were conducted repeatedly until data saturation was achieved. Observations focused on children's cognitive behaviors during learning and daily activities at home and school, including classification, problem-solving, attention, and social interaction. Relevant documents, such as learning notes and school records, were examined to contextualize behavioral data. All data were audio-recorded, transcribed verbatim, anonymized, and securely stored.

Data analysis employed a thematic analysis approach conducted in three coding cycles: open coding using sensitizing concepts from Piagetian theory, Bronfenbrenner's bioecological model, and neurocognitive constructs; axial coding to group codes into analytical categories (e.g., classification ability, conservation understanding, emotional regulation, and parenting patterns); and selective coding to synthesize overarching themes explaining cognitive development patterns across levels of family stimulation. Intercoder agreement was applied, with a second qualitative researcher independently coding approximately 25% of the data, followed by discussion to reach consensus. Credibility was ensured through source and method triangulation, an audit trail, and prolonged engagement. Researcher reflexivity was addressed through reflexive field notes and peer debriefing to minimize interpretive bias and ensure that findings were grounded in participants' perspectives.

2.4 Research Ethics

Ethical principles were followed to protect participant safety and rights. Written informed consent was obtained from parents, explaining study objectives, child participation, benefits, and risks. Participants were informed of their right to participate voluntarily, refuse questions, or withdraw anytime. Interviews and observations were conducted sensitively, considering children's emotional states and rural socio-cultural norms. Data were used solely for academic purposes and securely stored, ensuring integrity and participant protection. This study obtained ethical approval from Muhammadiyah University of Purwokerto (No. A12-11/016-S.Re/LPPM/I/2026). All participants provided informed consent, accompanied by guarantees of anonymity, data confidentiality, and the right to withdraw from the study at any time without any consequences.

3. FINDINGS AND DISCUSSION

This study involved 20 informants, consisting of nine children aged 6–8 years, nine parents, and two classroom teachers. The distribution of informants, including age, role, and data collection methods, is presented in Table 1. The children were enrolled in grades 1–2 of elementary school in Pandanarum District, Banjarnegara Regency, a rural area characterized by an agricultural-based economy and strong communal social relations.

Table 1. Research Informants: Cognitive Development of Children Aged 6–8 Years Integrating Piaget's Theory and Neurocognitive Perspective

ID	Role / Position	Initial	Age	Data Collection Method
1	Child 1	A1	7 years	Semi-structured interview
2	Child 2	A2	8 years	Semi-structured interview
3	Child 3	A3	6 years	Semi-structured interview, observation
4	Child 4	B1	8 years	Semi-structured interview
5	Child 5	B2	7 years	Semi-structured interview, observation
6	Child 6	B3	7 years	Semi-structured interview
7	Child 7	B4	8 years	Semi-structured interview, observation
8	Child 8	B5	6 years	Semi-structured interview
9	Child 9	B6	7 years	Semi-structured interview
10	Parent A1	O1	40 years	Semi-structured interview
11	Parent A2	O2	32 years	Semi-structured interview
12	Parent A3	O3	37 years	Semi-structured interview
13	Parent B1	O4	29 years	Semi-structured interview
14	Parent B2	O5	31 years	Semi-structured interview
15	Parent B3	O6	34 years	Semi-structured interview
16	Parent B4	O7	36 years	Semi-structured interview
17	Parent B5	O8	35 years	Semi-structured interview
18	Parent B6	O9	37 years	Semi-structured interview
19	Teacher Class 1	G1	45 years	Semi-structured interview
20	Teacher Class 2	G2	41 years	Semi-structured interview

***Source**: Research Informants, 2025*

Table 1 presents the distribution of 20 informants, divided into three groups: children aged 6–8 years, parents, and teachers. Most children were aged 7–8 years, corresponding to Piaget's concrete operational stage, which makes them suitable for examining classification, conservation, and basic problem-solving abilities. Data were collected through semi-structured interviews, with some children also observed, providing a comprehensive and accurate depiction of their behavior and thinking processes in real-life contexts. The combination of age, role, and data collection methods clarifies each informant's contribution to the study's analysis of cognitive development.

3.1 General Research Information

This study was conducted in the rural area of Pandanarum District, Banjarnegara, focusing on children aged 6–8 years who were enrolled in grades 1–2 of elementary school. The findings indicate that children's cognitive development is influenced not only by the level of environmental stimulation (high, moderate, low) but also by the interaction of biological factors (Piaget's cognitive developmental stages), socio-cultural factors (Bronfenbrenner's ecological systems), and learning environments from a neurocognitive perspective characteristic of rural contexts.

Table 2. Coding Based on Piaget–Bronfenbrenner–Neurocognitive Theory

Verbatim Quote	Initial Code	Category	Main Theme	Integrative Interpretation
"If the tall glass and the short glass have the same amount, right Bu..." (A3, 6 years)	Volume conservation	Stable conservation understanding	High stimulation	Child has reached the concrete operational stage (Piaget), supported by a strong family and school microsystem (Bronfenbrenner), with stable attention and working memory (Neuro).
"The tall one seems more… but the teacher said it's the same." (B2, 7 years)	Conservation unstable	Transition to concrete logic	Moderate stimulation	Child is in the transition from late preoperational to early concrete operational stage (Piaget), with inconsistent family support (Bronfenbrenner) and moderate neurocognitive function with fluctuating focus (Neuro).
"The tall one is more, because it looks full." (B5, 6 years)	Dominant visual perception	Intuitive thinking	Low stimulation	Child remains in the preoperational stage (Piaget), lives in a weak microsystem with minimal support (Bronfenbrenner), and shows low executive function and short attention span (Neuro).
"I encourage him to speak his opinion at home..." (O2, mother A2)	Supportive communication	Active family support	Strong microsystem	Consistent verbal support from parents (Bronfenbrenner) strengthens internalization of concrete logic (Piaget) and stabilizes attention–working memory function (Neuro).
"During study, after five minutes he switches to singing." (O5, mother B2)	Permissive parenting	Fluctuating support	Moderate microsystem	Unstable parenting (Bronfenbrenner) reduces focus (Neuro) and prevents stable concrete logical thinking (Piaget).
"I let him study by himself, sometimes I help." (O8, mother B4)	Minimal guidance	Low support	Weak microsystem	Weak family support (Bronfenbrenner) lowers social stimulation, slowing executive function activation and cognitive transition (Piaget–Neuro).
"He is very focused, eyes glued to the board." (G1, teacher)	Stable attention	High focus	Optimal executive function	Strong attention (Neuro) enhances conservation processes (Piaget) through responsive school environment (Bronfenbrenner).
"During study I like to look out the window, sometimes there are birds." (B4, 8 years)	Easily distracted	Unstable focus	Moderate executive function	Fluctuating attention (Neuro) limits consistent concrete thinking (Piaget) due to less structured learning environment (Bronfenbrenner).
"I study so Mama doesn't scold me." (B5, 6 years)	External self-regulation	Low motivation	Weak executive function	Social-pressure-based regulation (Neuro) shows low learning independence (Piaget), influenced by unsupportive family relationships (Bronfenbrenner).

"Sometimes I just play alone, afraid of being laughed at." (B6, 7 years)	Social isolation	Low self-confidence	Low socio-emotional aspect	Low emotional support (Bronfenbrenner) reduces sense of security, affecting social development and concentration (Neuro), making concrete logic development difficult (Piaget).

Source: *Data analysis results, 2025*

Table 2 presents the integration of cognitive, socio-ecological, and neurocognitive perspectives in understanding children's development. The table shows how verbatim statements from children, parents, and teachers were coded into categories and themes, highlighting the interaction of Piaget's cognitive stages, Bronfenbrenner's ecological support, and neurocognitive functioning.

1. High-stimulation group: Children such as A3 demonstrate stable conservation understanding and logical reasoning, reflecting full readiness to enter Piaget's concrete operational stage. Strong family and school support (Bronfenbrenner) and stable attention and working memory (Neurocognitive) enable consistent cognitive performance.
2. Moderate-stimulation group: Children such as B2 exhibit transitional cognitive development. They begin to apply concrete logic but remain influenced by visual perception. Fluctuating family support and moderate neurocognitive capacity contribute to unstable cognitive performance, requiring external scaffolding from teachers.
3. Low-stimulation group: Children such as B5 rely heavily on intuitive reasoning and visual perception, indicative of the preoperational stage. Limited family support, low socio-emotional security, and weak executive function restrict cognitive development.

Overall, the table demonstrates a clear pattern: cognitive development is strongest when high stimulation, consistent socio-ecological support, and optimal neurocognitive function converge. In contrast, insufficient stimulation and weak social support are associated with delays in logical reasoning, executive functions, and learning independence.

3.1.1 High-Stimulation Group

This group is classified as high-stimulation because the children receive intensive verbal stimulation and consistent environmental support, primarily from family and school. Results in the high-stimulation group show complex communication skills, understanding of story context, and the ability to answer analytical questions. Intensive verbal stimulation through reading and discussion activities has been proven to strengthen executive functions, including working memory and emotional regulation. One child stated: "*If the tall glass and the short glass have the same amount, right Bu.* At first, I thought the tall one had more, but if full, they are the same." (A3, 6 years). This statement indicates that the child is able to overcome visual perception bias and understands the principle of conservation.

From Bronfenbrenner's perspective, these children receive strong support from the family microsystem and the school mesosystem. Parents actively assist, as expressed by one mother: "*I encourage him to express his own opinion at home. If he is wrong, I correct gently*." (O2, mother of A2). This support accelerates the child's cognitive development in a rural environment (Yang & Eunjoo Oh, 2024). Neurocognitively, stable working memory and attention capacity allow the child to internalize simple abstract concepts. The teacher affirmed: "He is very focused, eyes glued to the board." (G1). This aligns with findings that attention stability supports the development of executive functions (Misgav & Daniel, 2022).

Analysis shows that at the Piagetian level, children demonstrate stable conservation and concrete logical thinking. At the Bronfenbrenner ecological layer, family and teacher support forms a synergistic microsystem; while neurocognitively, executive functions such as working memory and attention operate optimally. The dominant factor in this group is the synergy between intensive verbal stimulation and strong socio-ecological support, which accelerates the biological maturation of executive functions.

Figure 1. Children with High Stimulation

3.1.2 Moderate-Stimulation Group.

This group is called moderate-stimulation because the children receive inconsistent stimulation, mainly from parenting that sometimes supports but is often lax. The results align with Piaget's description of the transitional phase, where children begin to move away from intuitive thinking but have not fully stabilized in using concrete logic. One child stated: *"The tall one seems to have more… but the teacher said it's the same."* (B2, 7 years). This statement indicates that although the child begins to recognize that the volume of water remains the same, they are still influenced by the visual perception of the container. The teacher also emphasized: *"Moderate-stimulation children still need 2–3 repetitions. If there are multiple criteria, they get confused."* (G1).

From Bronfenbrenner's perspective, moderate-stimulation children usually receive inconsistent family support. Parents sometimes assist, but often leave the child to learn independently. One mother said: *"When studying, after five minutes they switch to singing. They are just little kids."* (O6, mother of B2). This shows permissive and inconsistent parenting, resulting in fluctuating cognitive development (Zou, 2023).

Neurocognitively, moderate-stimulation children have moderate working memory and fluctuating attention. They can remember simple instructions but require repeated reinforcement to retain information. The teacher noted: *"Moderate-stimulation children often look around. When focused, it's only briefly before daydreaming."* (G2). This indicates that children in this group need intensive scaffolding from teachers to maintain focus and strengthen working memory (Rie & Rie, 1979).

At the Piagetian level, children show cognitive transition toward concrete logic; at the Bronfenbrenner ecological layer, social support is unstable due to permissive parenting and limited home–school communication; neurocognitively, working memory and attention capacity are moderate but not yet stable. The dominant factor in this group is inconsistent socio-ecological stimulation, causing suboptimal development of brain biological functions (working memory–attention), so logical thinking is not stable. Therefore, the moderate-stimulation group demonstrates inconsistent cognitive development. They need more stable environmental support, both from family and school, to strengthen the transition toward the concrete operational stage.

Figure 2. Children with Moderate Stimulation

3.1.3 Low-Stimulation Group

This group is categorized as low-stimulation because the children experience minimal cognitive stimulation and family support, primarily due to very limited parental involvement. The results show that children tend to judge based on visual perception without considering quantitative aspects. Limited literacy activities at home and caregiving by substitute caregivers restrict cognitive and social stimulation. This condition highlights the importance of family involvement in providing concrete and meaningful learning experiences. One child said: *"The tall one seems to have more because it looks so full."* (B5, 6 years). This statement indicates that the child has not yet understood the principle of volume conservation and relies only on visual perception. Another child added: "I study so I don't get scolded by Mom." (B5, 6 years), confirming that their learning motivation is external rather than intrinsic.

From Bronfenbrenner's ecological perspective, low-stimulation children generally live in family microsystems with minimal support. Parents are busy working, so caregiving is often delegated to grandparents or older siblings. One mother admitted: *"I let them study alone, sometimes I help. If they are lazy, it's fine."* (O7, mother of B4). Teachers also noted: *"Low-stimulation children often stay silent in class, slump in the corner, and don't join activities."* (G1). Limited family communication and weak home–school relationships (mesosystem) are major factors hindering cognitive development (Y. Xu et al., 2022).

Neurocognitively, low-stimulation children show weaknesses in working memory, attention, and self-regulation. The teacher stated: *"Low-stimulation children get bored very easily, daydream after a short time. When asked to repeat, they usually sulk, 'I can't do it, Ma'am.'"* (G1). This aligns with findings (Morgan et al., 2019) that weak executive function worsens cognitive developmental delays. Moreover, socio-emotional aspects are also affected. One child said: *"Sometimes I play alone, afraid of being laughed at."* (B6, 7 years). This indicates social isolation and low self-confidence, further hindering cognitive and social development.

At the Piagetian level, children show dominance of visual perception and intuitive thinking characteristic of the preoperational stage; at the Bronfenbrenner ecological layer, family social support is weak, and the mesosystem is disconnected; neurocognitively, executive function is low, working memory is weak, and self-regulation is underdeveloped. The dominant factor in this group is the weakness of the family microsystem and minimal social stimulation, which impedes neurocognitive activation and slows concrete logical development. Thus, the low-stimulation group exhibits serious obstacles in cognitive development. Without consistent family support and intensive school intervention, these children are at risk of stagnation in executive function development.

Figure 3. Children with Low Stimulation

3.1.4 Integrative Interpretation of Child Cognitive Development Based on Three Theories

Cross-theory analysis shows that the cognitive development of children aged 6–8 years in rural areas is not determined solely by age, but by the interaction between cognitive developmental stages (Piaget), ecological support (Bronfenbrenner), and neurocognitive capacity. Studies (T. Xu & Zhang, 2021) emphasize that concrete thinking strategies can be enhanced through appropriate environmental stimulation. Bronfenbrenner highlights the importance of the relationship between microsystems and mesosystems in shaping children's resilience and development (Yang & Eunjoo Oh, 2024). Esearch (Howard, Vasseleu, Neilsen-Hewett, de Rosnay, & Williams, 2022) also shows that self-regulation and attention are strong predictors of early childhood academic success.

Integration across theories reveals a clear causal relationship: socio-ecological stimulation (Bronfenbrenner) affects the activation of neurocognitive functions (working memory, attention, self-regulation), which in turn determines the speed at which children reach the concrete operational stage (Piaget). The quality of family–school interaction serves as a primary mediator between social support and the biological maturation of brain function. Children with high stimulation experience a synergistic effect between a supportive environment and neurocognitive readiness, leading to rapid development of logical thinking. Children with moderate stimulation undergo partial transition due to inconsistent support, whereas low-stimulation children remain at intuitive thinking patterns due to weak social and neurofunctional support. Thus, cognitive development in rural children is shown to be the result of the interaction of three systems: cognitive structure (Piaget), ecological context (Bronfenbrenner), and brain biological functions (Neurocognitive), which are causally interconnected in shaping children's learning readiness.

3.1.5 Child Cognitive Development Based on the Integration of Piaget, Bronfenbrenner, and Neurocognitive Theories

The results of this study confirm that the cognitive development of children in rural areas highly depends on environmental stimulation. Children with high stimulation can demonstrate concrete logical thinking abilities according to Piaget's stage (Pakpahan & Saragih, 2022), supported by responsive families and active schools (Khan & Uddin, 2020). In contrast, children with low stimulation remain stuck in pre-operational thinking, worsened by weak family support, minimal home–school communication, and limited neurocognitive function (Rosen et al., 2020).

Teachers play a crucial role in bridging this gap through differentiated learning strategies, the use of concrete media, and empathetic approaches. However, without family and social environment support, teacher interventions are often unsustainable. Thus, the cognitive development of children aged 6–8 years in rural areas results from a complex interaction between cognitive developmental stages, ecological support, and neurocognitive capacity. Effective interventions must involve synergy among family, school, and community to ensure children can develop optimally.

In rural areas, children aged 6–8 years are theoretically at the concrete operational stage. However, actual achievement heavily depends on the manipulative experiences available in their surroundings. A3 demonstrates stable volume conservation *("At first, I thought the tall one had more, but it's actually the same"),* reflecting Piaget's concrete operational stage. Neurocognitively, attention is stable and working memory is strong, supported by visual and verbal learning strategies *("first picture, read the picture book again, then work on it").*

From Bronfenbrenner's ecological perspective, a responsive family *microsystem ("I encourage him to express his opinions at home…")* strengthens the mesosystem interaction between home and school. The integration of three factors—biological (maturation of executive functions), social (support from family and school), and neurocognitive (attention–working memory)—promotes optimal cognitive development. The dominant driving factor for A3 is the synergy between intensive family support and strong self-regulation capacity, enabling the child to engage in independent logical reflection.

B2 demonstrates an unstable understanding of conservation *("The tall one seems to have more… but the teacher said it's the same"),* indicating a transition between the pre-operational and concrete operational stages (Piaget). Neurocognitively, the child has moderate working memory and fluctuating attention, evident in the tendency to get easily distracted during learning. The family microsystem shows permissive parenting and inconsistent support *("When studying, after five minutes he starts singing"),* while the home–school mesosystem remains one-way. The integration of these three approaches illustrates that unstable interactions between social support and biological capacity result in partial cognitive development. The dominant inhibiting factor is the weak continuity of family stimulation, causing the child to rely on the teacher as the sole source of scaffolding.

B5 still thinks intuitively *("The tall one has more because it looks really full"),* indicating the dominance of visual perception typical of the pre-operational stage (Piaget). From Bronfenbrenner's perspective, the child lives in a family microsystem with minimal support ("I told him to study by himself; if he's lazy, that's it") and experiences social isolation *("I just play alone, afraid of being laughed at").* Neurocognitively, the child shows low self-regulation and external motivation *("I study so I won't be scolded by Mom").* The integration of the three theories illustrates a negative interaction between underdeveloped biological structures, limited social context, and weak executive functions. The dominant inhibiting factor is low socio-emotional support, which directly impacts weak self-regulation and logical thinking abilities.

This study emphasizes that in rural areas, the main challenge is not only limited resources but also the lack of integration among biological, social, and neurocognitive support. Verbatim statements from children and parents reinforce these findings as follows:

"If he makes a mistake, I correct him gently and give him a chance to try again." (Mother A3)
"I hug Mom. Or read a princess book." (B1)
"I cried, then didn't study anymore." (B5)

The findings emphasize that improving the quality of learning in rural areas cannot rely on a single approach. A comprehensive strategy is required, combining concrete stimulation, socio-emotional support, and meaningful learning experiences to optimally develop children's cognitive potential. Based on this foundation, the next section will discuss how the three main dimensions—biological (Piaget), socio-cultural (Bronfenbrenner), and neurocognitive—interact in shaping the cognitive achievements of children aged 6–8 years in rural environments.

3.2 Discussion

This study identified the dynamics of cognitive development in children aged 6–8 years in rural areas using an integrative approach combining Piaget's theory, Bronfenbrenner's ecological framework, and a neurocognitive perspective. The findings emphasize that the quality of environmental stimulation plays a decisive role in children's cognitive achievement, often more significantly than chronological age alone.

3.2.1 Cognitive Development and the Concrete Operational Stage

Findings show that children with high stimulation have reached the concrete operational stage according to the Piagetian framework, reinforcing that multiple classification, conservation understanding, and cause–effect logic are key indicators of cognitive transition in early school-age children (Hayat et al., 2024). Piaget emphasized that children at this stage begin to think logically about concrete objects, organize information systematically, and understand the principle of reversibility (Lehalle, 2020). However, this study indicates that such achievements are not universal for children aged 6–8 years in rural settings. Children with low stimulation still exhibit pre-operational thinking patterns, characterized by reliance on direct perception and difficulty in understanding volume conservation (Pakpahan & Saragih, 2022). This contrasts with findings from urban-based studies, which often report earlier and more consistent mastery of conservation and classification tasks due to richer cognitive stimulation, greater access to learning resources, and more structured educational environments (Seginer, 2006; Wiseheart & Munakata, 2008).

These results reinforce critiques of age as the sole indicator of development and support the view that social experience and the quality of interactions have a more significant impact on cognitive maturity (Risyanindya et al., 2024). Research (T. Xu & Zhang, 2021) confirms that concrete thinking strategies can be enhanced through appropriate environmental stimulation, including the use of concrete media, reflective dialogue, and classification activities. Thus, achieving the concrete operational stage is not solely the result of biological maturation but a product of active interaction between the child and their environment, particularly within under-resourced rural contexts.

3.2.2 Role of Developmental Ecology: Microsystem and Mesosystem

Bronfenbrenner's ecological model provides a comprehensive framework for understanding how the environment influences child development (Tudge, Merçon-Vargas, Liang, & Payir, 2022). This study shows that children with high stimulation generally exist within active family microsystems, where parents engage in learning activities, dialogue with the child, and provide emotional and cognitive scaffolding (Masters, Hirsh-Pasek, Levine, & Golinkoff, 2022). The mesosystem connecting home and school further strengthens this support, creating synergy between formal and informal educational actors (Yang & Eunjoo Oh, 2024).

In n contrast, children with low stimulation are often cared for by grandparents or older siblings, with minimal parental involvement due to work demands. Communication between home and school is limited, creating a weak mesosystem that does not optimally support child development (Y. Xu et al., 2022). Studies (Zou, 2023) indicate that the quality of interaction between systems, especially between family and school, plays a key role in shaping resilience and learning motivation in children. these findings reinforce the idea that educational interventions in rural areas cannot be individualistic. Systemic support involving family, school, and community is essential for the success of child development programs. In this context, Bronfenbrenner's theory is not only relevant conceptually but also serves as a basis for community-based educational policy formulation.

When compared with urban-based research (Luo et al., 2022) and (Otero-Mayer et al., 2025), where home–school communication tends to be more structured and frequent, the rural context reveals a critical ecological gap (Luo et al., 2022). These findings reinforce the idea that educational interventions in rural areas cannot be individualistic. Systemic support involving family, school, and community is essential for the success of child development programs (Otero-Mayer et al., 2025). In this context, Bronfenbrenner's theory is not only a relevant concept but also serves as a basis for community-based educational policy formulation.

3.2.3 Neurocognitive Perspective: Working Memory, Attention, and Self-Regulation

The neurocognitive dimension in this study indicates that children's internal capacities, such as working memory, attention, and self-regulation, act as mechanisms linking environmental stimulation to cognitive achievement (Albert et al., 2020). Children with high stimulation demonstrate strong working memory, can maintain attention for 20–30 minutes, and exhibit good self-regulation, including coping skills and persistence in completing tasks (Misgav & Daniel, 2022).

In contrast, children with low stimulation show weak working memory, easily distracted attention, and low self-regulation, such as quickly giving up and reluctance to retry tasks. Research (Morgan et al., 2019) indicates that weaknesses in executive function correlate with lower academic performance and delayed language development. Studies (Howard et al., 2022) further support these findings, showing that self-regulation and attention are strong predictors of early academic success. Therefore, the neurocognitive approach not only explains variations in cognitive achievement but also provides a foundation for more precise interventions, such as working memory training, attention-enhancement strategies, and emotion-based learning.

Unlike many neurocognitive studies that focus primarily on internal brain mechanisms without ecological framing, this study demonstrates that executive functions do not develop in isolation (Niebaum & Munakata, 2022). Instead, neurocognitive capacity is strongly shaped by ecological conditions, particularly the consistency of stimulation within the family and school environment (Rakesh et al., 2024). This integrative approach highlights that interventions targeting executive function must be embedded within supportive social contexts to be effective.

3.2.4 Synthesis of Children's Cognitive Development Based on the Integration of Piaget, Bronfenbrenner, and Neurocognitive Theories

The integration of the three perspectives—Piaget, Bronfenbrenner, and neurocognitive—provides a strong foundation for understanding child development in a multidimensional manner. This study demonstrates that children's cognitive achievements are not the result of a single factor but rather a complex interaction between internal and external structures. The main empirical contribution of this research is the identification of three stimulation profiles (high, medium, low), each showing distinct cognitive, ecological, and neurocognitive development patterns. These profiles can serve as a basis for designing contextual, differentiated, and needs-based educational interventions for children in rural areas.

Theoretically, this study extends Piaget's application by showing that the transition to the concrete operational stage can be accelerated through appropriate environmental stimulation. It also reinforces the relevance of Bronfenbrenner's ecological model in rural contexts, which is often overlooked in international literature. The neurocognitive perspective adds an additional dimension, explaining the internal mechanisms underlying children's success or difficulty in internalizing cognitive concepts.

3.2.5 Nuanced and Unexpected Findings: The Moderate-Stimulation Group

An important and nuanced finding of this study concerns the moderate-stimulation group, which does not fit neatly into a linear developmental trajectory. Unlike children in the high-stimulation group, these children show inconsistent mastery of conservation and classification tasks; however, they also demonstrate greater potential for cognitive transition compared to the low-stimulation group. This instability suggests that cognitive development in this group is highly sensitive to fluctuations in environmental support (Rakesh et al., 2024).

From an ecological perspective, inconsistent parenting practices and irregular home–school communication appear to create discontinuities in cognitive scaffolding (Seginer, 2006). Neurocognitively, moderate stimulation is associated with fluctuating attention and partially developed working memory, which may explain why children can perform tasks successfully in some contexts but fail in others (Wiseheart & Munakata, 2008). This finding is significant because it challenges binary categorizations of cognitive development and highlights the existence of a "developmental threshold" where targeted intervention could produce substantial gains (Seginer, 2006; Wiseheart & Munakata, 2008).

3.2.6 Role of Teachers and Ecosystem Synergy

Teachers have a strategic role in bridging the stimulation gap among children (Lurie et al., 2021). Differentiated learning strategies, the use of concrete learning media, and empathetic approaches are key in supporting children with medium and low stimulation. However, the effectiveness of teacher interventions heavily depends on support from families and the community (Holmes, Reinke, Herman, Thompson, & Danforth, 2019). Without synergy between the microsystem and mesosystem, teacher interventions tend to be unsustainable. Therefore, teacher training programs in rural areas need to include aspects of family communication, understanding of child ecology, and neurocognitive strategies. In addition, education policies should encourage parental involvement through home–school communication forums, parenting training, and the strengthening of learning communities.

3.2.7 Practical Implications

The findings of this study indicate that the cognitive development of children aged 6–8 in rural settings is not solely influenced by age but is heavily determined by the level of stimulation at home and school. The integration of Piaget's theory, Bronfenbrenner's ecological framework, and the neurocognitive perspective emphasizes that verbal stimulation, concrete experiences, and the quality of interactions within the microsystem directly affect executive functions, such as working memory and attention. This underscores the importance of contextualized learning, parental support, and strengthening home–school collaboration to accelerate the development of logical thinking skills in children in rural areas.

4. CONCLUSION

This study concludes that the cognitive development of children aged 6–8 in rural areas results from the interaction between Piagetian cognitive structures, Bronfenbrennerian social-ecological contexts, and neurocognitive capacities, rather than merely age or biological factors. Children with high stimulation demonstrate concrete logical thinking, conservation, and dual classification abilities, whereas children with moderate stimulation are in the transitional phase from preoperational to early concrete operational, showing emerging but fluctuating logical skills. In this group, children can perform basic categorization and begin to understand cause-and-effect relationships but still require verbal support and concrete examples to stabilize their reasoning. Meanwhile, children with low stimulation in rural areas continue to exhibit intuitive and egocentric thinking patterns. These findings are reinforced by Bronfenbrenner's framework, showing that the quality of microsystems—especially family–school relationships—and neurocognitive capacities such as working memory and self-regulation are heavily influenced by environmental stimulation levels. Integratively, the findings emphasize that rural children's cognitive development is driven by the synergy of brain biological maturation, socio-ecological support, and concrete daily learning experiences. Positive interaction among these factors accelerates children's transition to the concrete operational stage, particularly for moderately stimulated children who require reinforced scaffolding to stabilize their logical thinking. Practically, this highlights the importance of providing context-based cognitive stimulation, differentiated and contextualized learning, and strong collaboration among families, schools, and rural communities. Teachers need to offer concrete learning experiences, while families provide consistent verbal, social, and emotional stimulation.

The qualitative interview-based approach of this study offers in-depth insights but has limitations in generalizability, especially across diverse rural contexts. Further research is recommended using mixed-methods designs to more precisely measure the relationship between stimulation levels—including moderate stimulation—and cognitive outcomes. Longitudinal studies are necessary to monitor the stability of rural children's cognitive development over time, while cross-cultural studies could enrich understanding of ecological and neurocognitive variations across different rural settings.

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