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Longitudinal Analysis of Cognitive Transitions: A Case Study on the Evolution of Pre-operational to Concrete Operational Mindsets in Children Aged 5–7

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ABSTRACT
Background: The transition from pre-operational to concrete operational thinking is a fundamental stage in children's cognitive development. Despite its importance, classroom practices often prioritize early mastery of literacy and numeracy through memorization, with limited attention to children's developmental readiness. As a result, learning difficulties at an early age are frequently interpreted as indicators of limited ability rather than as part of a normal cognitive transition.
Aims: This study explores how a child's cognitive processes changed between the ages of five and seven, with particular attention to the development of logical reasoning during the transition from the pre-operational to the concrete operational stage.
Methods: A qualitative longitudinal single-case study was conducted over a two-year period involving one purposively selected child. Data were gathered through participatory observations, Piagetian clinical interviews, and an analysis of learning portfolios. The data were examined using a constant comparative approach, and evidence from multiple sources was triangulated to strengthen the trustworthiness of the findings.
Results: The child gradually shifted from intuitive, perception-based responses to more systematic and logical reasoning. Initial dependence on concrete representations in arithmetic was replaced by conceptual understanding, accompanied by stronger metacognitive awareness, independent reasoning, and more reflective approaches to problem solving.
Conclusion: The findings indicate that early academic difficulties should be interpreted within the context of cognitive development rather than as evidence of low intellectual ability. Recognizing individual developmental trajectories can help educators design learning experiences that encourage reasoning, inquiry, and conceptual understanding instead of emphasizing memorization alone.

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Introduction

Understanding how children develop the capacity to think logically has become one of the central concerns in educational research because cognitive readiness strongly influences the way knowledge is acquired and applied in classroom settings. As educational systems increasingly emphasize academic achievement from the earliest years of schooling, children are often expected to master literacy and numeracy skills before the underlying cognitive structures required for abstract reasoning have fully matured (Józsa et al., 2022). Although early academic exposure may provide learning opportunities, expectations that exceed children's developmental readiness can create a mismatch between instructional practices and cognitive capacity, potentially reducing the effectiveness of learning experiences (Buchberger, 2023). Contemporary perspectives on child development therefore argue that educational practices should be grounded not only in curriculum standards but also in an understanding of how children's reasoning evolves over time (Goddu & Gopnik, 2024; Howard & Ferrari, 2022). Recognizing developmental differences is particularly important during early childhood, when rapid changes in cognitive organization shape children's ability to interpret, classify, and solve problems in increasingly systematic ways. Consequently, examining cognitive development from a developmental rather than purely academic perspective remains essential for designing learning environments that are both meaningful and developmentally appropriate.

Across many educational contexts, children's academic performance during the early years is frequently evaluated using indicators such as reading fluency, writing accuracy, and rapid arithmetic calculation. While these indicators are valuable, they often become the primary benchmarks for determining school readiness, leaving limited consideration for the developmental progression of children's reasoning abilities (Józsa et al., 2022). Recent studies have shown that children who require more time to construct conceptual understanding are sometimes perceived as having lower academic potential, despite demonstrating strengths in other domains of cognition, including visual-spatial reasoning, creativity, and problem solving. Such assumptions may encourage instructional practices that emphasize memorization and repetitive exercises instead of inquiry, exploration, and conceptual learning. As a consequence, children whose cognitive development follows a different trajectory may experience unnecessary academic pressure, reduced learning confidence, and fewer opportunities to develop higher-order thinking skills (Chiong & Lim, 2022; Ssemugenyi, 2023). These conditions highlight the importance of understanding cognitive development as a gradual process that cannot be adequately evaluated through early academic achievement alone.

The transition between the ages of five and seven represents one of the most dynamic periods in cognitive development because children gradually reorganize their thinking from intuitive judgments toward logical reasoning. During this stage, they begin to understand relationships among objects, recognize causal connections, and solve problems using increasingly systematic mental processes rather than relying solely on perceptual cues (Jiao et al., 2024). Educational decisions made during this period therefore have long-term implications, as instructional approaches that align with children's cognitive readiness are more likely to promote meaningful learning than those emphasizing procedural memorization alone (Odegard & Gierka, 2026). Recent developmental research also indicates that children's reasoning abilities do not progress uniformly, with considerable individual variation in the pace and sequence of cognitive change (Schlatter et al., 2021). These differences suggest that evaluating children exclusively through age-based academic expectations may overlook important developmental characteristics that influence how they construct knowledge. Consequently, investigating cognitive change across this transitional period is essential for developing educational practices that are responsive to individual developmental trajectories rather than relying on standardized assumptions about children's learning readiness.

Understanding cognitive development requires more than identifying the characteristics associated with particular developmental stages; it also requires examining how children's reasoning gradually changes as they interact with their environment over time. Cognitive growth is a continuous process shaped by experience, exploration, and the progressive reconstruction of existing knowledge rather than by abrupt shifts between developmental stages (Cherukunnath & Singh, 2022; Cossart & Khazipov, 2022). Consequently, observing the same child across different developmental periods offers opportunities to capture subtle changes in reasoning that may remain hidden in cross-sectional comparisons involving different individuals. This perspective is particularly relevant because children's responses to similar learning situations often evolve through repeated experiences, allowing researchers to identify not only developmental outcomes but also the processes through which those outcomes emerge. From an educational perspective, such evidence can help explain why children with comparable chronological ages frequently demonstrate different levels of conceptual understanding and problem-solving ability. Therefore, a developmental perspective that follows cognitive change longitudinally provides a more comprehensive foundation for understanding individual learning trajectories and for designing educational practices that respect the natural pace of children's intellectual development.

Recent studies have consistently demonstrated that children's cognitive development is closely associated with learning environments that encourage active exploration, meaningful interaction, and conceptual understanding rather than repetitive memorization. Inquiry-oriented instruction, play-based learning, and problem-solving activities have been widely reported to strengthen reasoning skills, metacognitive awareness, and cognitive flexibility during early childhood (Konca, 2022). Other studies have further emphasized that children's readiness to understand mathematical and scientific concepts depends not only on chronological age but also on the gradual maturation of underlying cognitive processes, including symbolic representation, logical classification, and causal reasoning (Tunalı & Aktürkoğlu, 2025). Parallel evidence has also highlighted the importance of visual-spatial experiences and creative expression as foundations for later conceptual learning, suggesting that imagination and logical reasoning develop in complementary rather than competing ways (Bîzoi & Bîzoi, 2026; Clement, 2022). Collectively, these findings reinforce the view that cognitive development should be understood as a dynamic and multidimensional process that extends beyond the acquisition of early academic skills. Nevertheless, much of the existing evidence has been generated from studies examining groups of children at a single point in time, providing only limited insight into how individual reasoning evolves throughout developmental transitions.

Despite the growing body of research on children's cognitive development, several important limitations remain unresolved. Most contemporary studies have examined cognitive abilities by comparing different groups of children across age levels or by evaluating the effectiveness of instructional interventions at a single stage of development (Bati, 2022; Park, 2021). While these approaches have contributed valuable evidence regarding developmental characteristics, they provide only a snapshot of children's reasoning and offer limited understanding of how cognitive structures are gradually reconstructed within the same individual over time. Moreover, previous investigations have predominantly emphasized measurable learning outcomes, such as academic achievement or school readiness, with considerably less attention devoted to the developmental processes through which intuitive reasoning evolves into logical thinking (Al-Hashim & Alalouch, 2025; Buchberger, 2023). Longitudinal qualitative evidence that documents cognitive transformation through repeated observations, clinical interviews, and authentic learning artifacts remains particularly scarce, especially within the context of Indonesian early childhood education. Addressing this gap is important because a deeper understanding of individual cognitive trajectories may provide richer insights into children's developmental readiness than conclusions drawn solely from cross-sectional comparisons or standardized academic assessments.

Building upon these considerations, the present study investigates how cognitive reasoning develops during the transition from the pre-operational to the concrete operational stage by following the same child over a two-year period. Rather than focusing solely on developmental outcomes, this study seeks to understand how logical thinking gradually emerges through everyday learning experiences, interactions, and cognitive reconstruction. By employing a qualitative longitudinal case study design, the research provides a detailed account of developmental processes that are often overlooked in cross-sectional investigations. The findings are expected to extend current perspectives on Piagetian cognitive development by illustrating how individual reasoning evolves across a critical developmental transition within an authentic educational context. From a practical perspective, the study offers evidence that may assist educators and parents in designing learning experiences that are more responsive to children's cognitive readiness instead of relying primarily on age-based academic expectations. Ultimately, this research contributes to a more comprehensive understanding of children's cognitive development and reinforces the importance of aligning educational practice with the natural progression of children's intellectual growth.

Method

Research Design

This study employed a qualitative longitudinal single-case study to investigate the cognitive transition of a child from the pre-operational stage to the concrete operational stage over a two-year period. A qualitative approach was selected because the study sought to understand how cognitive reasoning developed through naturally occurring learning experiences rather than to quantify developmental outcomes. The longitudinal design enabled continuous observation of the same participant across two critical developmental stages, allowing changes in reasoning, conceptual understanding, and problem-solving strategies to be examined as they emerged over time. Unlike cross-sectional studies that compare different individuals at a single point in time, a longitudinal case study provides a richer understanding of developmental processes by capturing the continuity of cognitive change within the same individual. The study was guided by Piaget's theory of cognitive development, particularly the transition from pre-operational thinking to concrete operational reasoning, which served as the conceptual framework for interpreting the participant's cognitive development.

Participants

The study involved a single participant selected through criterion purposive sampling because the objective was to obtain an in-depth understanding of cognitive development within a naturally occurring context rather than to achieve statistical generalization. The participant was a child who was five years old at the beginning of the study and was followed continuously until reaching seven years of age. Selection was based on four inclusion criteria: (1) demonstrating typical developmental characteristics without identified cognitive or developmental disorders; (2) participating in formal early childhood education before entering primary school; (3) remaining accessible throughout the two-year observation period; and (4) receiving parental consent to participate in the study. The participant's identity has been anonymized to protect confidentiality, and written informed consent was obtained from the parent prior to data collection. Throughout the research process, observations were conducted within the participant's regular learning environments to ensure that the study did not interfere with daily educational experiences.

Instruments

In qualitative research, the researcher functioned as the primary instrument responsible for observing, interpreting, and synthesizing the data. To enhance the depth and credibility of the findings, four complementary sources of evidence were employed. The first instrument was a participatory observation guide developed to record the participant's cognitive behaviors during learning activities. Observations focused on indicators derived from Piagetian cognitive development theory, including symbolic representation, logical reasoning, causal understanding, classification, seriation, conservation, and problem-solving strategies. The second instrument consisted of Piagetian clinical interview protocols designed to explore the participant's reasoning processes underlying observable behaviors. Open-ended questions encouraged the participant to explain how conclusions were reached, thereby revealing patterns of cognitive construction beyond correct or incorrect responses. The third source of evidence was portfolio documentation, including drawings, mathematical worksheets, written assignments, science-related activities, and other learning artifacts collected throughout the two-year observation period. These materials enabled longitudinal comparisons of the participant's cognitive development across different developmental stages. Finally, reflective field notes were prepared following each observation session to document contextual information, methodological reflections, emerging interpretations, and unexpected events that supported subsequent data analysis.

Procedures

Data collection was conducted over a two-year period and followed a structured longitudinal procedure designed to document the participant's cognitive transition from the pre-operational stage to the concrete operational stage. The study commenced with participant selection using criterion purposive sampling, followed by baseline observations when the participant was five years old. During this initial phase, participatory observations, Piagetian clinical interviews, and portfolio documentation were conducted to establish the participant's initial cognitive profile.

The second phase consisted of continuous longitudinal monitoring across the following two years. Observations were undertaken within the participant's natural learning environments, while interviews and portfolio collections were conducted at key developmental milestones to document changes in logical reasoning, conceptual understanding, symbolic representation, and learning behaviors. The final phase was completed when the participant reached seven years of age, during which follow-up observations and interviews were undertaken to identify characteristics associated with concrete operational thinking. After all qualitative evidence had been collected, data obtained from multiple sources were integrated through methodological triangulation before proceeding to the analytical stage. The complete research procedure is illustrated in Figure 1.

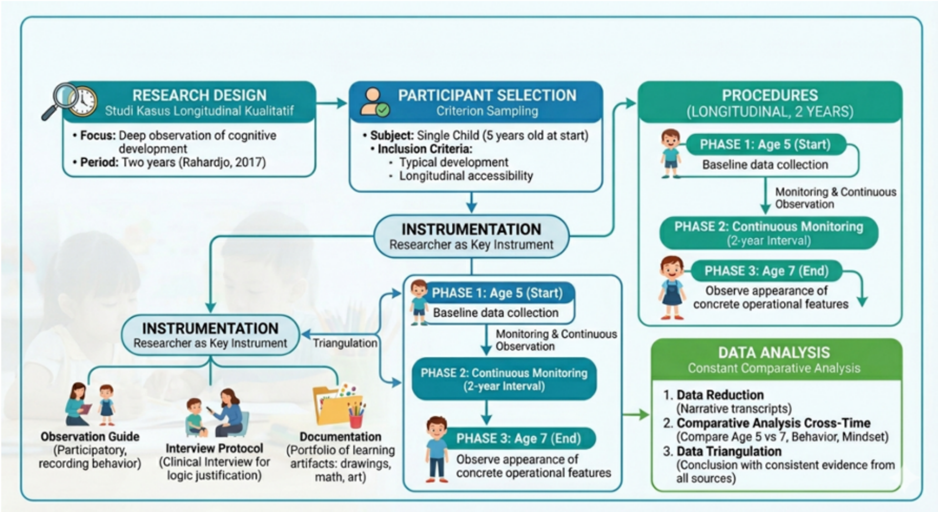

Figure 1. Research Procedure of the Longitudinal Qualitative Single-Case Study

Following the procedure illustrated in Figure 1, qualitative evidence from observations, interviews, portfolio documentation, and reflective field notes was accumulated continuously throughout the study. This longitudinal process enabled the researcher to document cognitive development as it naturally evolved rather than relying on isolated observations conducted at a single point in time.

Data Analysis

Data were analyzed using the constant comparative method, which enabled cognitive development to be examined continuously across different observation periods. The analysis began with organizing observation records, interview transcripts, portfolio documents, and reflective field notes into a comprehensive dataset. The researcher repeatedly reviewed all qualitative evidence to gain familiarity with the data before conducting open coding to identify meaningful units related to logical reasoning, symbolic representation, causal understanding, classification, and conceptual understanding.

Codes representing similar concepts were subsequently grouped through axial coding to establish broader analytical categories describing the participant's cognitive development. Relationships among these categories were then examined through constant comparison across observation periods and data sources to identify recurring developmental patterns. Finally, overarching themes were developed to explain the participant's transition from pre-operational to concrete operational thinking. The credibility of the findings was strengthened through methodological triangulation by comparing evidence obtained from observations, interviews, portfolio documentation, and reflective field notes. An audit trail documenting coding decisions and analytical interpretations was maintained throughout the study to enhance the dependability and confirmability of the findings, while rich contextual descriptions support the transferability of the results to similar educational settings.

Results and Discussion

Results

The research findings demonstrate a significant cognitive transformation in the subject over the two-year period. At age five, the subject exhibited characteristics of intuitive thinking, perceiving scientific phenomena primarily as visual changes without comprehending the underlying logical mechanisms. In terms of numeracy, the subject faced substantial hurdles with arithmetic operations exceeding the capacity of their fingers, largely due to an internal resistance to rote-memorization methods commonly practiced by their peers. This resistance occasionally triggered academic frustration; however, the subject simultaneously displayed superior imagination and symbolic representation. The subject's cognitive transformation is summarized in Table 1 below.

Tabel 1. Longitudinal Comparison of the Subject's Cognitive Transformation (Ages 5 and 7)

Dimension of Observation	Findings at Age 5 (Pre-operational Phase)	Findings at Age 7 (Concrete Operational Phase)	Cognitive Evolution (Analysis)
Scientific Understanding (Capillarity)	Perceived phenomena solely as visual changes. Recognized color shifts but lacked understanding of "why."	Became critical and questioned beyond the visible. Sought causal mechanisms outside of immediate perception.	Transition from intuitive-magical thinking to reasoning based on causality.
Numerical Logic (Addition)	Relied on finger counting and rote memory. Experienced frustration when figures exceeded the number of fingers.	Recognized that rote memorization is obsolete. Developed mathematical proficiency through a logical understanding of number concepts.	A shift from physical dependence (fingers) and mechanical rote-learning toward logical abstraction.
Creativity & Imagination	Exceptionally high. Capable of creating imaginative works with greater detail than peers.	Imagination remained present but became more structured and critical. Capable of logically reflecting on early childhood works.	Transformation of free imagination into directed critical thinking.
Attitude Toward Learning	Tended to feel inadequate or frustrated when forced into mechanical rote-learning (experienced cognitive conflict).	Appeared proficient and confident. Rejected rote-learning in favor of logical exploration.	Emergence of independent thinking and metacognitive awareness.
Response Toward Peers	Felt left behind as peers successfully utilized rapid rote-memorization.	Outperformed peers due to a deeper understanding of logical concepts (quality over speed).	Proof that logic-based learners achieve superior long-term mastery compared to rote-learners.

Analysis of the learning portfolio revealed a stark contrast in the subject's approach to numeracy tasks. At age five, worksheets frequently showed corrections and signs of frustration when dealing with numbers greater than 10. Observations noted that the subject often ceased working when their fingers could no longer represent the quantity, as they refused to memorize results without concrete visualization. Conversely, at age seven, the portfolio demonstrated mature abstraction. The subject no longer required physical aids and could explain numbers as a conceptual system. In one interview session, the subject retrospectively stated, "I used to only memorize that $5 + 6$ is 11 because I was told so, but now I know why it is 11," indicating a developed metacognitive awareness of their learning process (Zamzami & Zamzami, 2025).

Clinical interview data during the transitional phase (ages 6.5 to 7) showed an increased frequency of complex questioning. While at age five the subject passively accepted scientific phenomena (e.g., merely admiring color changes in plants), by age seven, they began questioning hidden variables. This active inquiry provides evidence of the subject's readiness for formal primary education (Mufrihah, 2021). The subject displayed skepticism toward superficial answers and sought logical validation for new information. This suggests that the earlier resistance to rote-learning was actually an early manifestation of a robust critical thinking character (Widana & Widyastiti, 2023).

Furthermore, art portfolio observations indicate that at age 5, the subject possessed exceptional symbolic representation skills. Unlike peers who typically produced "tadpole" figures, the subject generated complex objects from memory, such as the solar system with its orbits and intricate mechanical details on vehicles. This suggests that despite hurdles in mechanical-mathematical operations, the subject maintained high cognitive functioning in visual memory and spatial reasoning. This holistic information processing the ability to store complex mental imagery and accurately reproduce indicates a mature semiotic function, which served as a foundation for critical thinking at age 7. Prior research corroborates that visual perceptual abilities significantly influence a child's academic performance (Sugiasih & Setiowati, 2016).

Discussion

One of the most important findings of this study is the participant's gradual transition from intuitive, perception-based reasoning at the age of five to more organized and logically structured thinking by the age of seven. This progression indicates that cognitive development should be understood as a continuous process of reorganizing mental structures rather than as an abrupt change between developmental stages. During the early phase of observation, the participant interpreted phenomena primarily through immediate perception and personal experience, whereas later observations revealed an increasing ability to explain events using causal relationships and logical connections. This developmental pattern closely reflects Piaget's proposition that children progressively construct more sophisticated cognitive schemas through the complementary processes of assimilation and accommodation as they interact with their environment (Hanfstingl et al., 2022; *Piaget's Stages of Cognitive Development*, n.d.). Rather than simply reaching a new developmental stage because of chronological age, the participant's reasoning appeared to evolve through repeated opportunities to reconstruct existing knowledge in response to increasingly complex experiences. Recent studies similarly emphasize that logical reasoning develops through continuous interaction between maturation and meaningful learning experiences rather than through biological maturation alone (Donovan et al., 2021; Mualem et al., 2024). From this perspective, the present findings reinforce the view that cognitive development is best understood as a dynamic process of conceptual reconstruction, providing empirical support for developmental theories that emphasize gradual intellectual transformation during early childhood.

Another noteworthy finding concerns the participant's initial difficulty with arithmetic tasks that depended heavily on rote memorization. At first glance, such difficulties might be interpreted as evidence of limited mathematical ability; however, the longitudinal evidence suggests a different explanation. Rather than resisting numerical concepts themselves, the participant appeared reluctant to accept mathematical procedures that lacked meaningful conceptual representation. This pattern is consistent with Piaget's view that children construct mathematical understanding by coordinating actions and relationships before they are able to manipulate abstract symbols efficiently (Shvarts, 2025; Wei et al., 2024). The participant's reliance on concrete representations, such as finger counting and visual reasoning, therefore reflected an age-appropriate developmental strategy rather than a cognitive deficit. Similar observations have been reported in recent studies indicating that conceptual understanding provides a stronger foundation for long-term mathematical competence than memorization of isolated procedures (Ncube & Luneta, n.d.). Nevertheless, the present findings extend previous research by demonstrating that temporary delays in procedural fluency may coexist with advanced conceptual reasoning when children are allowed to develop according to their individual cognitive trajectories. This perspective challenges educational practices that equate rapid computational performance with mathematical competence and instead highlights the importance of recognizing conceptual growth as a meaningful indicator of cognitive development.

An equally important finding is that the participant consistently demonstrated strong visual-symbolic abilities despite experiencing difficulties with conventional arithmetic during the early stage of the study. This combination suggests that different cognitive functions may develop at different rates, indicating that weaknesses observed in one academic domain should not automatically be interpreted as evidence of overall cognitive limitations. The participant's detailed drawings and ability to mentally represent complex objects illustrate the development of semiotic function, which Piaget regarded as a fundamental precursor to higher-order reasoning because it enables children to manipulate internal representations independently of immediate perception. From this perspective, visual-symbolic competence appears to have provided an important cognitive foundation upon which later logical reasoning and conceptual understanding were constructed. Contemporary research likewise recognizes that visual-spatial processing, symbolic representation, and executive functions contribute substantially to children's mathematical reasoning and scientific thinking, particularly during the transition toward more advanced cognitive structures (Whitehead & Hawes, 2023). However, previous studies have generally examined these cognitive domains separately, whereas the present longitudinal evidence illustrates how early strengths in symbolic representation may progressively support the emergence of logical reasoning within the same individual. This finding therefore extends current understanding by suggesting that visual-symbolic competence should be viewed not merely as an artistic ability but as an integral component of children's cognitive architecture that facilitates subsequent conceptual development across academic domains.

Taken together, the findings suggest that cognitive development follows an individualized developmental trajectory rather than a uniform sequence determined solely by chronological age. Although Piaget proposed that children generally progress through invariant developmental stages, the present study demonstrates that the pace at which different cognitive functions mature may vary considerably within the same developmental period. The participant's early difficulties with procedural arithmetic occurred alongside advanced symbolic representation and growing curiosity, indicating that different dimensions of cognition can progress asynchronously before becoming integrated into more coherent logical reasoning. This interpretation is consistent with contemporary developmental perspectives, which emphasize that cognitive growth is shaped by continuous interactions among biological maturation, environmental experiences, and opportunities for meaningful learning rather than by age-related maturation alone (Klotzbier & Schott, 2024; Leisman et al., 2025). Recent studies have likewise reported substantial individual variation in children's developmental pathways, although most have described these differences by comparing groups of children rather than documenting cognitive change within the same individual over time. By tracing cognitive development longitudinally, the present study illustrates how seemingly unrelated abilities gradually converge into more sophisticated patterns of reasoning, thereby providing a more nuanced understanding of developmental continuity than is typically captured in cross-sectional research. Consequently, these findings enrich the interpretation of Piagetian theory by emphasizing that developmental stages should be viewed as dynamic processes of cognitive reorganization rather than as fixed categories determined exclusively by age.

Beyond confirming established perspectives on cognitive development, the present findings offer an alternative lens for understanding how developmental readiness should be interpreted in educational practice. Contemporary research has increasingly acknowledged that children exhibit considerable diversity in the pace and pattern of cognitive growth, yet educational systems continue to rely heavily on age-based academic benchmarks as indicators of learning readiness (Buchberger, 2023; Zeeshan et al., 2025). This reliance often obscures the developmental processes through which logical reasoning gradually emerges, particularly among children whose conceptual understanding develops ahead of procedural fluency. The present study demonstrates that temporary delays in conventional academic performance may coexist with the progressive construction of sophisticated cognitive structures, a relationship that has received comparatively little attention in previous longitudinal investigations. While recent studies have emphasized the importance of inquiry-based learning, conceptual instruction, and child-centered pedagogy for fostering cognitive development (Michala et al., 2026; Normatovna, 2026), relatively few have documented how these developmental processes unfold continuously within the same child across a critical transitional period. By integrating repeated observations, clinical interviews, and authentic learning artifacts, this study provides process-oriented evidence that complements existing outcome-oriented research. Consequently, the findings help bridge an important gap in the literature by illustrating not only what developmental changes occur during early childhood but also how those changes are progressively constructed through everyday learning experiences.

Overall, the present study highlights that cognitive development during early childhood is better understood as a dynamic process of knowledge construction than as the attainment of predetermined developmental milestones. The longitudinal evidence demonstrates that logical reasoning emerges through the gradual integration of symbolic representation, conceptual understanding, and reflective thinking, rather than through isolated gains in academic performance (Acosta et al., 2024; Demetriou et al., 2023). This perspective reinforces the relevance of Piaget's developmental framework while also extending its educational interpretation by illustrating how individual cognitive trajectories unfold within authentic learning environments. The findings further suggest that educational practices should move beyond evaluating children's readiness solely through procedural achievement and instead recognize the diverse pathways through which conceptual understanding develops. Such an orientation is particularly important in early childhood education, where premature emphasis on memorization and standardized performance may obscure children's underlying cognitive potential. By documenting the developmental journey of a single participant over an extended period, this study provides detailed empirical evidence that complements broader quantitative findings and contributes to a more nuanced understanding of cognitive transition during one of the most formative stages of child development. Future longitudinal investigations involving multiple participants and diverse educational contexts would further enrich current knowledge by examining whether similar developmental patterns are observed across children with different learning experiences, cultural backgrounds, and instructional environments.

The educational implications of these findings extend beyond the interpretation of a single developmental case and invite a broader reconsideration of how children's learning progress is evaluated during the transition from early childhood education to primary school. Educational systems frequently prioritize observable academic performance, particularly early proficiency in reading, writing, and arithmetic, because these outcomes are easily measured and compared across learners. The present findings suggest that such an emphasis may overlook important developmental characteristics, particularly among children whose conceptual understanding matures through exploration and reasoning rather than through rapid procedural acquisition. From a constructivist perspective, meaningful learning occurs when children actively reorganize existing knowledge in response to new experiences, making cognitive growth fundamentally dependent on opportunities for inquiry, reflection, and conceptual exploration rather than repetitive practice alone. Recent educational research similarly advocates for learning environments that encourage reasoning, collaboration, and authentic problem solving as foundations for sustainable cognitive development (Williamson, 2023). Consequently, the present study provides additional empirical support for educational approaches that evaluate children's developmental readiness through the quality of their thinking processes instead of relying exclusively on standardized academic indicators. Such an orientation may contribute to more inclusive educational practices by recognizing that developmental diversity represents a natural characteristic of children's learning rather than a deviation from expected academic performance.

Although the present study focuses on a single participant, its contribution lies in providing a detailed developmental narrative that reveals aspects of cognitive change that are often difficult to capture through large-scale quantitative investigations. Rather than seeking statistical generalization, this study offers analytical insights into the processes through which logical reasoning gradually emerges during one of the most important transitions in childhood development. These insights complement existing developmental research by illustrating the temporal dynamics of cognitive reconstruction within authentic educational contexts, thereby enriching current interpretations of Piagetian theory from a process-oriented perspective (Çoban Sural & Yaşar Sağlık, 2026). At the same time, the findings should be interpreted within the boundaries of the study's design, as individual developmental trajectories may be influenced by family environments, educational experiences, cultural contexts, and personal characteristics that were not examined in depth. Future research involving multiple longitudinal cases, diverse educational settings, and interdisciplinary perspectives from developmental psychology, neuroscience, and learning sciences would provide valuable opportunities to examine the consistency of these developmental patterns across different populations. By integrating longitudinal observation with rich qualitative evidence, the present study demonstrates the value of examining cognitive development as an evolving process rather than as a sequence of isolated developmental outcomes, thereby offering a perspective that contributes to ongoing international discussions on children's learning and cognitive growth.

Implications

The findings of this study offer meaningful implications for both the advancement of cognitive development theory and educational practice. The longitudinal evidence illustrates that children's cognitive growth cannot be adequately understood through isolated observations or age-based academic expectations alone. Instead, cognitive development emerges through an ongoing process in which symbolic representation, conceptual understanding, and logical reasoning gradually become integrated as children interact with their learning environments. By documenting this developmental progression within the same individual, the study provides additional empirical support for interpreting Piagetian cognitive development as a dynamic process of cognitive reorganization rather than a rigid sequence of age-dependent stages. This perspective broadens current discussions on developmental variability by emphasizing that children may follow different pathways while ultimately constructing comparable logical competencies. The study also carries practical implications for early childhood education. Educational decisions are frequently influenced by children's early performance in literacy and numeracy, often placing greater emphasis on procedural accuracy than on the quality of reasoning. The developmental pattern observed in this study suggests that such an approach may overlook important aspects of children's cognitive potential, particularly among those who require more time to construct conceptual understanding before demonstrating procedural competence. Creating learning environments that encourage questioning, exploration, and meaningful problem solving may therefore provide more appropriate opportunities for cognitive growth than instructional approaches centered primarily on repetition and memorization. Viewing children's learning progress through a developmental perspective may also help educators and parents make more balanced educational decisions while reducing the risk of prematurely labeling children whose cognitive strengths emerge through different developmental pathways.

Limitations

The findings should be interpreted in light of several limitations. First, the study was intentionally designed as a qualitative longitudinal single-case investigation, with the primary objective of developing an in-depth understanding of cognitive transition within one individual rather than producing statistically generalizable conclusions. Consequently, the developmental pathway described in this study should be understood as one possible illustration of cognitive change, recognizing that children's experiences are shaped by diverse personal, educational, and sociocultural circumstances.

A second limitation relates to the contextual scope of the investigation. Although the two-year observation period provided valuable opportunities to document developmental change as it naturally occurred, the study focused primarily on observable learning behaviors, clinical interviews, and portfolio evidence. Other influences that may contribute to cognitive development, such as family interaction patterns, classroom instructional differences, peer relationships, and broader environmental factors, were not examined systematically. Furthermore, the study concentrated specifically on the transition between the pre-operational and concrete operational stages; therefore, the findings should not be interpreted as representing the full complexity of cognitive development across childhood. Recognizing these boundaries is important for interpreting the findings appropriately while also identifying directions for further investigation.

Suggestions

Building upon the present findings, future research could extend this line of inquiry by following a larger number of children across different educational settings and sociocultural contexts. Examining multiple developmental trajectories would make it possible to identify both common patterns and individual variations in the emergence of logical reasoning, thereby strengthening current understanding of cognitive development during early childhood. Longitudinal studies that integrate qualitative observations with complementary developmental assessments may also provide a more comprehensive picture of how conceptual understanding evolves over time. From an educational perspective, further investigations should explore how different instructional approaches influence children's cognitive transition beyond conventional measures of academic achievement. Particular attention could be directed toward learning environments that encourage inquiry, conceptual exploration, collaborative problem solving, and reflective thinking, as these experiences may contribute to the construction of deeper cognitive understanding. Comparative studies involving different pedagogical approaches would also be valuable in identifying educational practices that best support diverse developmental pathways. Such evidence could assist educators, curriculum developers, and policymakers in designing learning experiences that recognize cognitive diversity while promoting meaningful and sustainable learning throughout early childhood education.

Conclusion

This study demonstrates that the transition from the pre-operational stage to the concrete operational stage represents a gradual process of cognitive reorganization rather than a simple progression determined by chronological age. Through a two-year qualitative longitudinal case study, the findings reveal that the participant's development from intuitive, perception-based reasoning toward more systematic and logical thinking was accompanied by the integration of symbolic representation, conceptual understanding, and reflective reasoning. The study further indicates that early difficulties with procedural arithmetic should not be interpreted as evidence of limited cognitive ability, as they may instead reflect an ongoing process of constructing deeper conceptual knowledge. These findings reinforce Piaget's theory of cognitive development while offering a more process-oriented perspective by illustrating how cognitive change unfolds within authentic learning experiences over time. From an educational standpoint, the study underscores the importance of evaluating children's learning readiness through the quality of their reasoning rather than relying exclusively on early academic performance or age-based expectations. Although the findings are derived from a single participant and are intended for analytical rather than statistical generalization, they provide detailed longitudinal evidence that enriches current understanding of children's cognitive development and highlight the value of developmentally responsive learning environments that encourage inquiry, conceptual exploration, and meaningful knowledge construction.

Author Contributions Statement

NAKD conceived and designed the study, developed the research framework, and conducted the entire research process, including participant selection, longitudinal data collection through participatory observations, Piagetian clinical interviews, portfolio documentation, and reflective field note preparation. The author independently performed data organization, coding, constant comparative analysis, interpretation of the findings, integration of the results with relevant theoretical and empirical literature, prepared the original manuscript, critically revised its intellectual content, approved the final version for publication, and accepts full responsibility for the accuracy, integrity, and originality of all aspects of the work.

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