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Implementation of Differentiated Learning in Stimulating Cognitive Intelligence of Early Childhood Learners: A Case Study at *Paud Attaqwa Bojonegoro* in the *Merdeka* Curriculum Framework

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ABSTRACT

This study explores the implementation of differentiated learning to stimulate cognitive intelligence in early childhood learners within the Merdeka Curriculum at *PAUD Attaqwa, Bojonegoro,* East Java. Cognitive intelligence during the golden age (0–6 years) includes logical thinking, problem-solving, classification, and working memory. Differentiated learning adjusts content, process, and product to children's readiness, interests, and learning profiles. Using a single-site qualitative case study over four months (October 2025 – January 2026), the study involved five educators and 38 children aged 4–6 years. Data were collected through participatory observation, semi-structured interviews, and document analysis, then analyzed using Miles, Huberman, and Saldaña's interactive model. Findings show that content differentiation through tiered materials, process differentiation via learning stations and flexible grouping, and product differentiation by allowing diverse expression collectively enhanced children's problem-solving, spatial logic, and self-efficacy. The synergy between differentiated learning, Vygotskian scaffolding, and the Merdeka Curriculum proved effective in optimizing cognitive development.

Keywords: cognitive intelligence, differentiated learning, early childhood, early childhood education, Merdeka Curriculum

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Introduction

Early childhood is widely recognised as the most critical period in human development. During the first six years of life, the brain undergoes rapid growth, forming neural connections at a pace that never recurs. It is during this window that foundational cognitive abilities such as logical reasoning, problem-solving, classification, and working memory begin to take shape. In Indonesia, the importance of early childhood education (ECE) is formally acknowledged in Law No. 20 of 2003 on the National Education System, which defines ECE as a holistic effort to nurture children's physical and spiritual growth from birth to age six. More than just a place for play, ECE is the primary investment in the nation's future human capital.

Yet, despite this recognition, ECE classrooms are characterised by high heterogeneity. In a single group, a teacher may find a child who can count to twenty while other struggles to recognise the number five; one child learns best through movement, another through listening. The Bojonegoro District Education Office (2023) reported that around 68 percent of ECE institutions in the region still apply uniform, one-size-fits-all teaching methods. This conventional approach not only ignores individual differences but also risks widening developmental gaps: fast learners become bored and disengaged, while slower learners fall behind and lose confidence (Handiyani & Muhtar, 2022).

Differentiated learning has emerged as a powerful, evidence-based response to this challenge. According to Tomlinson (2017), differentiated instruction is a teacher's proactive effort to modify three key elements content (what is taught), process (how children learn), and product (how they demonstrate understanding) based on students' readiness, interests, and learning profiles. In early childhood, differentiation is not merely about offering varied activities; it is about creating an inclusive environment where every child can learn at their own pace and in their own way. Research has shown that differentiation can increase motivation, engagement, and self-efficacy (Niswah & Zulfahmi, 2024; Schunk & DiBenedetto, 2021).

The Merdeka Curriculum (*Indonesian: Kurikulum Merdeka*), introduced through Permendikbudristek No. 12 of 2024 (and supported by earlier regulations No. 5 and No. 7 of 2022), provides a policy framework that aligns perfectly with differentiated learning. It emphasises child-centred, project-based learning and gives teachers the autonomy to design learning experiences that fit local contexts and individual children's potentials (Maryani & Sayekti, 2023; Munawar, 2022). However, while international studies have documented the benefits of differentiation in primary and secondary schools (Bondie et al., 2019; Karimi & Nazari, 2021; Kotas et al., 2023), research specifically focusing on its implementation in Indonesian ECE under the Merdeka Curriculum is still limited (Ngaisah, 2023; Sa'ida, 2023). This gap motivated the present study.

Three research questions guided this inquiry: (1) How is differentiated learning implemented at *PAUD Attaqwa* to stimulate children's cognitive intelligence? (2) Which aspect of differentiation content, process, or product has the most significant influence on cognitive development? (3) How does the synergy between differentiated learning and the Merdeka Curriculum help reduce cognitive developmental gaps among children?

Methods

This study employed a single-site qualitative case study design (Yin, 2018) because it allows for an in-depth, contextualised understanding of a contemporary phenomenon within its real-life setting. The researcher is the head of *PAUD Attaqwa Bojonegoro*, a dual role that provides deep insider access but also carries a risk of bias. To mitigate this, the researcher employed multiple strategies. First, source and method triangulation was conducted by comparing data from observations, interviews, and documents. Second, member checking was performed: each educator reviewed the preliminary findings to confirm interpretive accuracy. Third, peer debriefing was conducted with two external supervisors from another university who reviewed raw data (interview transcripts and observation notes) to ensure interpretative neutrality. Fourth, a reflective journal was maintained throughout the study to document personal assumptions and decisions. These measures align with trustworthiness criteria discussed by Creswell and Poth (2018).

The research site was *PAUD Attaqwa,* selected purposively based on three criteria: it had adopted the Merdeka Curriculum consistently since the 2022–2023 academic year; the institutional leadership demonstrated strong commitment to pedagogical innovation; and its semi-urban demographic profile is representative of many ECE institutions in East Java, enhancing analytical transferability. Participants included five educators (all female, teaching experience ranging from 3 to 12 years) and 38 children divided into Group A (15 children, aged 4–5 years) and Group B (23 children, aged 5–6 years). All educators were directly involved in planning and implementing differentiated learning.

Data collection was conducted over four months (October 2025 – January 2026), covering two complete thematic units: "My Self-Identity" and "Basic Needs". Three main instruments were used. First, participatory observation for 12 weeks, during which the researcher actively engaged in classroom activities and recorded teacher–child interactions using a structured observation guide. This guide was developed based on the cognitive indicators of the Merdeka Curriculum for ECE, which include: (a) ability to sort objects by one or two attributes (classification), (b) ability to complete puzzles with increasing piece counts (problem-solving), (c) ability to recognize and extend simple patterns (AB, ABC) (pattern reasoning), and (d) ability to verbally explain a simple process or creation (working memory and logical reasoning). Second, semi-structured interviews (2–3 sessions per educator, 45–60 minutes each) explored teachers' reasoning, perceptions of children's cognitive progress, challenges, and institutional support. All interviews were audio-recorded and transcribed verbatim. Third, document analysis of Daily Lesson Plans (RPPH), children's worksheets, anecdotal records, quarterly developmental reports, and portfolios of children's work.

Data analysis followed the interactive model of Miles, Huberman, and Saldaña (2020), consisting of four iterative stages: data condensation (open coding using NVivo software, followed by axial coding to group codes into themes), data display (thematic matrices and conceptual networks), conclusion drawing (inductively constructed), and verification (member checking). Ethical approval was obtained from the institutional review board. All adult participants signed informed consent forms; for children, parental consent was obtained, and children were given age-appropriate explanations and the right to decline participation. Pseudonyms are used in all reported data to protect confidentiality.

Results

The analysis produced three main themes corresponding to the three dimensions of differentiated learning: content, process, and product. These themes are not isolated but interact synergistically. Based on observational data, interview transcripts, and document analysis over four months, the following patterns emerged.

Content differentiation at PAUD Attaqwa was implemented by providing multiple levels of the same learning material, calibrated to each child's current readiness. Before each thematic unit, teachers conducted informal diagnostic assessments through observation and simple questioning. Based on this, they prepared two to three tiers of tasks for each cognitive activity. Table 1 summarises the strategies used for four core cognitive areas.

***Table 1**. Content Differentiation Strategies for Cognitive Intelligence Stimulation at PAUD Attaqwa*

Cognitive Aspect	Teacher Strategy	Example of Tiered Materials
Mathematical logic	Tiered complexity of number and symbol materials	Number boards: advanced children sequence 1–20; beginners focus on recognising symbols 1–10
Classification and categorisation	Variation of object attributes (colour, size, shape)	Sorting baskets: some children sort by one attribute (colour), others by two attributes (colour and size)
Problem-solving	Differentiation of puzzle complexity	Puzzles: 4–6 pieces for beginners; 12–20 pieces for children with higher spatial ability
Pattern reasoning	Variation in pattern complexity (AB, ABC, AABB)	Beading: simple alternating colours for some; three-element repeating patterns for others

One Group B teacher explained in an interview: "I cannot give all children the same task. If I force uniformity, the slower ones become frustrated and the faster ones get bored. I have to know where each child is and give them a challenge that is just a little above that." This statement reflects the principle of Vygotsky's Zone of Proximal Development (Smolucha & Smolucha, 2021). Document analysis of RPPH confirmed that every lesson plan included at least two levels of scaffolding, often with specific notes such as "for Alya: use number cards 1–10; for Rizki: use number cards 1–20 with missing numbers." Observational field notes documented many instances of responsive teaching: when a child unexpectedly completed a higher-level puzzle, the teacher quickly provided a more complex one without disrupting the rest of the class, indicating a high level of pedagogical competence (Puspitasari, 2024).

Process differentiation was the most dynamic and frequently observed dimension. The physical classroom was organised into several learning stations: a numeracy corner, a literacy corner, a construction corner, a sensory play area, and an art station. Children could move freely among stations, choosing activities that matched their preferred learning modality (visual, auditory, or kinesthetic). Table 2 provides examples of how teachers tailored process differentiation to different learning styles.

***Table 2**. Process Differentiation Based on Children's Learning Modalities*

Learning Modality	Activity Example	Cognitive Stimulation Target
Visual	Using colourful number charts and picture cards	Number recognition, pattern matching
Auditory	Singing counting songs, teacher read-aloud with questions	Sequential memory, listening comprehension
Kinesthetic	Beading, puzzle manipulation, construction with blocks	Fine motor coordination, spatial reasoning, problem-solving

Grouping was flexible and changed according to instructional goals: homogeneous grouping by ability level for activities requiring intensive guidance, and heterogeneous grouping for collaborative projects to encourage peer learning. Group compositions were rotated every two weeks based on updated developmental mapping from daily anecdotal records. Beading activities emerged as a clear favourite among children and as the most effective medium for process differentiation. One teacher noted: "Children who usually cannot sit still for five minutes will focus on beading for 15–20 minutes if the beads are colourful and the pattern is just right for them." During these activities, teachers used scaffolded questions rather than giving direct answers, for example asking "What colour came before? Look at the pattern again from the beginning." This approach encourages children to internalise problem-solving strategies (Smolucha & Smolucha, 2021). Peer scaffolding occurred naturally in heterogeneous groups: a more advanced child might show a peer how to thread beads in an AB pattern, benefiting both the helper (reinforcing understanding) and the recipient (receiving less intimidating support) (Yuliantina & Boki, 2023).

Product differentiation gave children meaningful choices in how they showed what they had learned. Instead of requiring all children to produce identical worksheets, teachers offered multiple expressive modes: drawing, three-dimensional construction, storytelling, or dramatic play. This aligns with the Merdeka Curriculum's emphasis on authentic assessment (Maryani & Sayekti, 2023). One of the most cognitively rich product-differentiation activities was creating picture frames from ice cream sticks and recycled cardboard, inviting children to explore concepts of structure, symmetry, spatial proportion, and stability all components of visual-spatial intelligence (Yuliani et al., 2024).

Portfolio analysis revealed a wide range of creations: some children built simple two-sided frames with geometric precision, others constructed ambitious three-dimensional frames, and some focused on elaborate decoration. Over the four-month period, three indicators of cognitive progression were identified from portfolios and anecdotal records: increasing complexity and ambition of products over time; growing accuracy and richness in children's verbal descriptions when asked to explain their work; and increasing initiative in choosing expressive media appropriate to the concept being communicated an early metacognitive sign. Table 3 summarises the observed progress across the participant group.

Table 3. *Summary of Children's Cognitive Progress Indicators*

Indicator	Number of Children Showing Progress
Increasing product complexity	30 of 38 children
Richer verbal explanations	28 of 38 children
Initiative in media selection	25 of 38 children
Progress on at least two indicators	33 of 38 children
Progress on all three indicators	28 of 38 children

Anecdotal records captured many "breakthrough" moments that occurred disproportionately during product-differentiated activities. For example, one child who had struggled with one-to-one correspondence suddenly showed clear understanding while arranging buttons on a frame, explaining: "This button is for the top corner, this one for the bottom, so they match." Such moments support the idea that freedom of expression enhances deep cognitive engagement (Komariah, 2023).

Children who showed slower progress. Of the 38 children, five (approximately 13 percent) did not demonstrate clear progress on at least two indicators. Further examination of their records revealed that three of these five had irregular attendance (less than 60 percent of days during the research period), one had a previously unidentified developmental delay (language-related), and one was in the process of transitioning from a different PAUD with a very different pedagogical approach. Teachers developed individual learning plans for these children, including more frequent one-on-one scaffolding sessions and simplified task tiers. However, the four-month period was insufficient to observe significant change. This finding underscores that while differentiated learning is powerful, it is not a magic solution; children with chronic absenteeism or specific developmental conditions require additional, sustained interventions beyond what a regular classroom differentiation model can provide.

Discussion

The findings of this study indicate that differentiated learning, when implemented holistically, can effectively stimulate cognitive intelligence in early childhood learners within the *Merdeka* Curriculum framework. The integration of content, process, and product differentiation at *PAUD Attaqwa* was not a mechanical checklist but a coherent pedagogical philosophy exactly as Tomlinson (2017) envisioned. This approach respects each child's unique learning style and developmental trajectory, which is the very essence of the Merdeka Curriculum (Munawar, 2022).

Four theoretical lenses help explain why differentiation appeared to work well in this setting. First, Piaget's theory of cognitive development (as discussed by Oogarah-Pratap et al., 2020) reminds us that children in the preoperational stage (ages 2–7) learn best through concrete, hands-on experiences. Content differentiation at *PAUD Attaqwa* consistently used manipulatives number boards, beads, puzzles, and construction sticks allowing children to physically interact with mathematical and spatial concepts. Second, Vygotsky's Zone of Proximal Development (Smolucha & Smolucha, 2021) provides a precise mechanism: by calibrating tasks to each child's ZPD boundary challenging but not overwhelming teachers maximised cognitive growth. The observed practice of "fading" (gradually reducing assistance as competence increased) is crucial for internalising cognitive strategies and fostering independence. Third, self-efficacy theory (Schunk & DiBenedetto, 2021) explains the motivational impact. When children

repeatedly experience success on appropriately challenging tasks, they develop a belief in their own ability, creating a self-reinforcing cycle. The *PAUD Attaqwa* teachers consciously designed tasks to ensure that every child could experience mastery, building a foundation for lifelong learning orientation (Handiyani & Muhtar, 2022). Fourth, the cultural-historical perspective highlights the role of learning media as cognitive tools. Numeral cards, beads, and recycled materials are not just props; they are mediators of thinking, and their careful selection to match each child's developmental level is a form of differentiation that often goes unnoticed but has significant instructional power (Komariah, 2023).

Comparison with prior studies strengthens the validity of these findings. Bondie et al. (2019) found that teachers' understanding of differentiation deepens through reflective practice exactly what happened at *PAUD Attaqwa*, where weekly team meetings provided space for sharing successes and difficulties. Pozas et al. (2021) emphasised the necessity of continuous diagnostic assessment; *PAUD Attaqwa* teachers had woven informal assessment seamlessly into daily routines.

Kotas et al. (2023) highlighted the value of teacher collaboration, which was evident in co-planning and resource sharing.

Real-world challenges were also identified: increased teacher workload due to planning three tiers of activities; material resource limitations in a semi-urban setting, which teachers compensated for by using locally available materials (recycled cardboard, bottle caps, ice cream sticks); and the need for sustained professional development, not just one-off training (Wijaya et al., 2025). Despite these challenges, the overall implementation proved feasible and beneficial.

Practical implications are clear. For educators, the first step is to develop the habit of continuous diagnostic assessment. For school principals, the priority is to build a school culture that values experimentation and collaboration, for example by scheduling weekly joint planning sessions. For policymakers, incorporating indicators of instructional responsiveness to child diversity into ECE accreditation standards would provide a strong incentive for wider adoption of differentiation across Indonesia.

Conclusions

This study concludes that differentiated learning, implemented systematically through content, process, and product differentiation, shows promise as an effective strategy for stimulating cognitive intelligence in early childhood learners at *PAUD Attaqwa Bojonegoro*. The approach appeared to reduce the negative effects of heterogeneity that often plague conventional ECE classrooms, enabling children of varying readiness levels to make meaningful cognitive progress. Improvements were observed in independent problem-solving, logical and pattern reasoning, spatial creativity, and self-efficacy. Theoretically, this study provides qualitative empirical evidence from an Indonesian semi-urban ECE context, integrating Tomlinson's differentiation model, Vygotskian scaffolding, and self-efficacy theory within the Merdeka Curriculum framework. Practically, it offers actionable recommendations: educators should prioritise diagnostic assessment; principals should foster collaborative planning cultures; and policymakers should embed responsiveness to diversity in accreditation standards. Future research should employ multi-site designs comparing urban PAUD (with abundant resources)

and rural PAUD (with limited resources) to identify contextual adaptation strategies. Mixed-methods studies with pre- and post-intervention cognitive measures, as well as longitudinal designs tracking children into primary school, would further illuminate the sustained impact of early differentiated learning experiences.

Declarations

1.1 Study Limitations

This study has several limitations. First, the single-site case study design limits statistical generalisation; the findings are analytically transferable rather than statistically representative. Second, the four-month data collection period, while sufficient to capture implementation patterns, could not assess long-term effects on children's readiness for primary school. Third, the absence of standardised cognitive assessment instruments precludes direct comparison with other quantitative studies. Fourth, the researcher's dual role as head of the institution, although mitigated through triangulation, external review of raw data, and member checking, may still have introduced subtle bias in interpreting certain classroom interactions. These limitations are openly recognised as part of the study's honest self-appraisal.

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1.4 Competing Interests

The author declares no financial or non-financial conflicts of interest. The dual role of the researcher as head of *PAUD Attaqwa* was mitigated through the rigorous reflexivity strategies described in the Methods section, including independent review of raw data by external researchers.

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