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Improving Cognitive Abilities in Early Childhood Through Color Experimental Method: A Case Study of Kindergartens in Muna Regency

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ABSTRACT

Improving cognitive abilities in early childhood is a crucial aspect of early childhood education because it forms the foundation for learning readiness at subsequent educational levels. This study aimed to analyze improvements in the cognitive abilities of children aged 5–6 years through the application of the color experiment method in learning activities. The study employed a classroom action research approach with a two-cycle design, with each cycle comprising planning, action implementation, observation, and reflection. The participants were 14 children aged 5–6 years. Research instruments included observation sheets for teacher and child activities, assessment sheets for children's cognitive abilities, limited interviews, and documentation of learning activities. Data were analyzed using descriptive quantitative and qualitative approaches. The results revealed a significant improvement in children's cognitive abilities from the initial observation to cycle II. Class-level cognitive achievement increased to 92.85% in cycle II, exceeding the predetermined success indicators. In addition, teachers' instructional activities and children's learning engagement also improved substantially following refinements in learning strategies. These findings indicate that the color experiment method is effective in enhancing children's cognitive abilities. The improvement was not limited to mastery of color concepts but also included the development of logical thinking, understanding of cause-and-effect relationships, and the ability to communicate observational outcomes. This study highlights the importance of implementing hands-on, experiential learning as an innovative strategy in early childhood education to optimize children's cognitive development.

Keywords:
Action research, cognitive abilities, color experiments, early childhood, kindergarten

INTRODUCTION

Early childhood refers to the age range of 0–6 years and is characterized by very rapid development across multiple domains, including physical, intellectual, social, emotional, and language development (Margono, 2018; Sukatin et al., 2023). This period is commonly referred to as the golden age because children show high sensitivity to environmental stimuli that support neurological and physiological maturation (Suryana et al., 2022). During this stage, child development occurs through complex interactions among physical growth, cognitive abilities, social interaction, emotional regulation, and language acquisition (Dewi et al., 2020). Therefore, early childhood is considered a strategic phase for laying the foundations of personality and essential abilities holistically (Tanu, 2017).

In the context of learning, early childhood education plays a strategic role as the primary foundation for developing children's overall potential. This level of education does not focus solely on early academic skills but also emphasizes the development of cognitive, language, social-emotional, artistic, and independence-related competencies (Hasyim, 2015; Wahyuni et al., 2025). These developmental aspects are closely interconnected and form an integrated whole. Delays in one domain may hinder progress in other areas (Maulana & Eliasa, 2024). Therefore, early childhood education must be designed systematically and sustainably to support children's development optimally.

In addition to serving as a developmental foundation, early childhood education functions as a bridge between the family environment and formal schooling, particularly in preparing children for primary education. Learning experiences at this stage should be diverse and meaningful to provide balanced stimulation across all developmental domains (Selvia & Nurachadijat, 2023). Such stimulation aims to support children's physical and psychological development, preparing them for subsequent levels of education (Puspita, 2020; Yeni et al., 2021). High-quality early childhood education also contributes to the development of self-confidence, creativity, and long-term learning motivation (Andriani et al., 2024). However, in practice, learning activities in early childhood education are often dominated by a passive approach. As a result, children have limited opportunities to explore and actively participate in the learning process. As a result, children have limited opportunities to explore and actively engage in the learning process.

One of the key developmental domains emphasized in early childhood education is cognitive ability. Cognitive development in children aged 3–6 years progresses rapidly and plays a critical role in determining readiness for subsequent educational levels (Ndai et al., 2023; Trenggonowati & Kulsum, 2018). Cognitive ability enables children to understand their environment, solve simple problems, and develop the foundations of logical and symbolic thinking (Haywood, 2020; Wahidah & Ummiyah, 2022). For this reason, fostering cognitive development from an early age is an essential component of early childhood education.

Conceptually, cognitive ability is associated with thinking processes that involve acquiring, processing, and applying knowledge. The cognitive domain includes stages such as knowledge, comprehension, application, analysis, synthesis, and evaluation (Khaeriyah et al., 2018; Suryameng & Marselina, 2019). In early childhood, cognitive development is reflected in learning and problem-solving abilities, logical reasoning, and symbolic thinking. These abilities can be observed through activities such as recognizing numbers and colors and understanding cause-and-effect relationships. Therefore, cognitive development is more effectively facilitated through learning methods that actively involve children in processes of discovery and direct experience.

The experimental method is one learning approach considered relevant for supporting cognitive development in early childhood (Khaeriyah et al., 2018). Hudaifah and Mashudi (2024) found that this method encourages curiosity and promotes deeper understanding in children. Through experimental activities, children are given opportunities to conduct simple experiments and directly observe objects and phenomena. This process supports problem-solving skills, stimulates creativity, and enables children to draw conclusions based on their own experiences (Addini, 2021). Previous studies have shown that simple science experiments can improve cognitive abilities in children aged 5–6 years (Fatimah, 2024). These improvements are particularly evident in color-mixing activities, especially in children's ability to recognize colors and communicate experimental outcomes (Fajriani & Liana, 2020; Fitri, 2021). However, most existing studies focus primarily on color recognition. Research that links color-based experimental methods to comprehensive cognitive development remains limited, particularly in early childhood education settings with constrained learning resources.

Initial observations conducted on March 6, 2025, at a kindergarten in Muna regency indicated that children's cognitive development had not progressed optimally. The findings revealed that cognitive abilities among children aged 5–6 years were relatively low. Of the 14 children observed, only a small proportion reached the very well-developed and developed as expected categories, while the majority remained in the developing and not yet developing categories. These results indicate a gap between expected cognitive development outcomes and classroom learning practices. The low level of cognitive development is presumed to be associated with the limited application of exploratory and child-centered learning approaches.

Based on these conditions, this study proposes novelty by applying a color experiment method as a systematically designed learning strategy to improve the cognitive abilities of children aged 5–6 years. The study aims to analyze improvements in children's cognitive abilities resulting from the implementation of the color experiment method. In addition, this research is expected to provide empirical contributions to the development of innovative learning practices in early childhood education. The findings are anticipated to enrich scientific discourse on experiment-based learning in early childhood settings and to serve as a reference for educators and researchers seeking to enhance the quality of early childhood education.

LITERATURE REVIEW

Theory of Cognitive Development in Early Childhood

Early childhood cognitive development can be understood through the framework of cognitive development theory, which emphasizes stages of thinking that evolve with age and maturity (Mu'min, 2013). At this stage, children are in a transitional phase toward more organized thinking skills (Rabindran & Madanagopal, 2020). During this period, children begin to use symbols to represent objects and engage in activities that enhance their cognitive abilities (Lestari & Prima, 2018). They start to group objects, understand simple cause-and-effect relationships, and use symbols to represent experiences (Borst & Houdé, 2022). However, children's thinking remains largely concrete, which means that effective learning should be grounded in real-world experiences that can be directly observed and manipulated.

In the context of early childhood education, cognitive development theory provides a foundation for understanding that appropriate stimulation accelerates the maturation of children's thinking functions. Irfani et al. (2025) emphasize that interactive stimulation significantly influences cognitive development, including thinking skills, memory, and problem-solving abilities. Learning activities that involve exploration, experimentation, and observation allow children to actively construct their own knowledge (Anggrian & Saefurahman, 2025). Therefore, learning approaches aligned with the cognitive characteristics of children aged 5–6 years should emphasize active involvement in the learning process.

Constructivist Approaches in Early Childhood Learning

The constructivist approach views children as active learners who construct knowledge through interaction with their environment. Direct experience and active engagement form the foundation for conceptual understanding from an early age (Belolutskaya et al., 2022). Within this perspective, learning is not regarded as a passive reception of information. Instead, it is understood as a process of meaning-making based on play, exploration, and social interaction (Wibowo et al., 2025; Zajda, 2021). Constructivist principles highlight the importance of contextual, relevant, and meaningful learning experiences that align with children's cognitive development stages and learning characteristics.

The implementation of constructivist approaches in early childhood education requires teachers to assume the role of facilitators who design learning environments rich in stimulation and capable of fostering curiosity (Gautam & Agarwal, 2023). Teachers are expected to provide activities that encourage children to ask questions, experiment, and discover concepts independently through play-based and exploratory learning (Aeni et al., 2023). This approach effectively supports early childhood cognitive development by offering opportunities for children to develop logical, reflective, and creative thinking skills appropriate to their developmental level (Belolutskaya et al., 2022).

Experimental Methods from an Active Learning Perspective

The experimental method is a learning strategy that aligns closely with the principles of active and constructivist learning. This method positions children as central participants in the learning process through activities such as experimenting, observing, and drawing simple conclusions from direct experiences (Bahar & Aksüt, 2020; Nafiqoh, 2025). In early childhood education, experimental methods are designed as simple, safe, and play-based activities. This design enables children to explore phenomena in their surroundings without academic pressure (Gelir, 2022). Consequently, children can learn through direct interaction with real objects and events that match their cognitive developmental stage.

Through experimental methods, young children acquire not only factual knowledge but also foundational thinking skills. These skills include observing differences, comparing outcomes, and solving simple problems independently (Anwar & Astuti, 2024; Nafiqoh, 2025). Research consistently shows that experiential learning is more effective than conventional approaches because it provides hands-on experiences that strengthen early understanding of science concepts, increase active engagement, and foster curiosity and learning motivation (Gelir, 2022; Wulandari et al., 2021).

Color Experiments as Early Childhood Science Activities

Color experimentation is a simple science activity that can be easily implemented in early childhood education. This activity involves concrete objects and visible changes that children can directly observe (Bakrisuk et al., 2024; Zahrah & Winarti, 2024). Color-mixing activities allow children to witness changes in real time, which aligns with the characteristics of early childhood thinking that remain within the preoperational stage and rely heavily on sensorimotor experiences (Sholikah et al., 2025). Through color experiments, children can learn about primary and mixed colors through hands-on experience rather than solely through teachers' verbal explanations (Afifa et al., 2024).

From the perspective of early childhood science learning, color experiments serve as a means to introduce basic scientific thinking processes, including observation, simple prediction, and communication of findings (Hidayat et al., 2023; Zahrah & Winarti, 2024). Several studies indicate that color-mixing activities support broader cognitive development, particularly in understanding cause-and-effect relationships and basic logical reasoning. This occurs when children associate initial colors with resulting mixed colors (Bakrisuk et al., 2024; Sholikah et al., 2025). Consequently, color experiments provide an important foundation for later science learning by offering early experiences of scientific inquiry through enjoyable and meaningful activities.

The Relationship between Color Experiment Methods and Cognitive Abilities

The color experiment method is closely associated with the development of cognitive abilities in children aged 5–6 years. Through color-mixing activities, children learn to classify, compare, and connect new information with prior knowledge (Bakrisuk et al., 2024; Sholikah et al., 2025). Gradually, children develop an understanding of cause-and-effect relationships, for example, when they recognize that combining specific colors produces different outcomes (Zahrah & Winarti, 2024). This process encourages active thinking and supports children's ability to interpret experimental results in ways that are consistent with their cognitive developmental stage.

Color experiments also help children develop the ability to communicate their observations, either verbally or through simple representations such as drawings or color symbols (Afifa et al., 2024; Hidayat et al., 2023). The capacity to express observational outcomes demonstrates integration between cognitive and language development. Children not only understand color concepts but also learn to articulate ideas and findings (Sholikah et al., 2025). Therefore, the color experiment method contributes not only to the acquisition of color concepts but also to broader cognitive development, particularly in logical thinking, simple problem-solving, and early scientific communication skills (Bakrisuk et al., 2024; Zahrah & Winarti, 2024).

The Relationship between Color Experiment Methods and Cognitive Abilities

Numerous studies have demonstrated that experimental methods positively influence early childhood cognitive development, particularly through simple science activities involving direct exploration (Bakrisuk et al., 2024; Sholikah et al., 2025). Research focusing on color experiments generally reports improvements in children's ability to recognize colors, conduct simple experiments, and display greater learning enthusiasm compared to lecture-based or passive demonstration approaches (Afifa et al., 2024; Zahrah & Winarti, 2024). These findings reinforce the view that experiment-based learning is more effective in stimulating active engagement and cognitive processing in early childhood.

However, most previous studies have concentrated on specific learning outcomes, such as color recognition or basic science process skills, without comprehensively examining cognitive development (Heryandini et al., 2023; Sholikah et al., 2025). Some research also assesses child development in a fragmented manner, focusing only on aspects such as color recognition or fine motor skills. As a result, these studies do not fully capture the relationship between color experiment methods and integrated cognitive skills, including logical thinking, problem-solving, and the ability to communicate learning outcomes (Hidayat et al., 2023).

This study extends previous research by examining the role of the color experiment method in enhancing the cognitive abilities of children aged 5–6 years more comprehensively. Rather than focusing solely on color concept mastery, this study also addresses logical thinking, simple problem-solving, and children's ability to communicate experimental results. These aspects are examined as part

of the integrated development of cognitive and language skills in early childhood (Bakrisuk et al., 2024; Zahrah & Winarti, 2024).

METHODOLOGY

Research Design

This study employed a classroom action research approach to improve the cognitive abilities of children aged 5–6 years through the application of color-experiment methods. This approach was selected because it enables systematic improvements to learning practices based on actual classroom conditions. In addition, classroom action research allows for continuous reflection, enabling learning strategies to be adjusted directly according to children's needs.

The study was conducted during the 2025/2026 academic year and involved 14 children aged five to six years, consisting of eight boys and six girls. Learning activities were designed and implemented in two instructional cycles. Each cycle was intended to address weaknesses identified in the previous cycle and to enhance children's cognitive achievement progressively.

The research design followed the cycle model proposed by Kemmis and McTaggart, which consists of four stages: planning, action implementation, observation, and reflection (Subekti, 2017). These stages form a cycle that is carried out sequentially and repeatedly. Reflection at the end of each cycle served as the basis for refining both planning and instructional implementation in the subsequent cycle. The classroom action research cycle used in this study is presented in Figure 1.

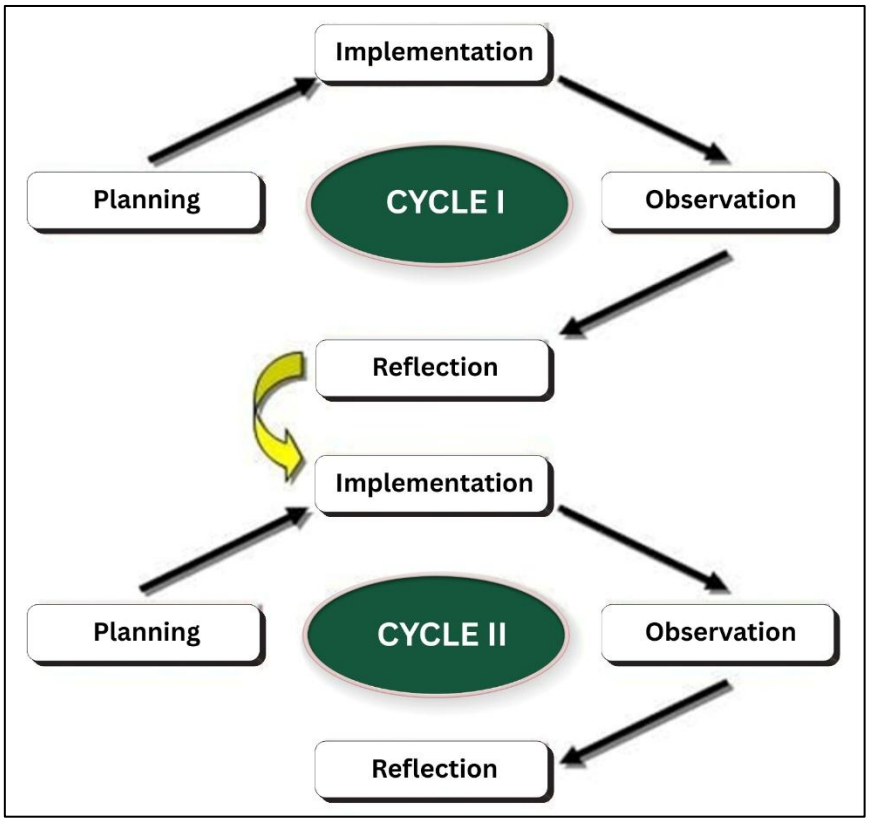

Figure 1. Classroom Action Research Cycle Model by Kemmis and McTaggart

Figure 1 illustrates the recurring process of classroom action research, consisting of planning, action implementation, observation, and reflection conducted across two learning cycles. Reflection at each stage functions as the foundation for improving subsequent instructional planning and practice. This model emphasizes that improvements in learning quality are achieved through a continuous and reflective process.

Instruments and Data Collection

The instruments used in this study included observation sheets designed to assess children's cognitive abilities based on developmental indicators for children aged 5–6 years. These indicators covered the ability to observe color changes, classify experimental outcomes, understand simple cause-and-effect relationships, and communicate experimental results. In addition to observation sheets, interview guidelines were used to support and enrich observational findings.

Data were collected using multiple techniques to ensure comprehensive and reliable information. Observations were conducted to document children's learning activities and the teacher's role during the implementation of the color experiment method. This technique allowed researchers to directly examine children's engagement at each stage of the learning process. In addition, limited interviews were conducted to obtain supplementary information regarding instructional implementation and children's responses to experimental activities. Documentation, including records of children's developmental progress, was also used as supporting data.

Data Analysis

Research data were analyzed using both quantitative and qualitative descriptive approaches. Quantitative analysis was conducted to determine the level of achievement of children's cognitive abilities based on predetermined developmental categories, as presented in Table 1.

Table 1. Criteria for Classical Learning Achievement

Percentage	Category
95%-100%	very well developed
85%-94%	developed as expected
75%-84%	beginning to develop
<75%	not yet developed

Table 1 served as the reference for determining children's cognitive achievement levels in each cycle. This analysis was used to compare learning outcomes across cycles and to evaluate improvements in cognitive abilities following the implementation of the color experiment method. The results of the quantitative analysis formed the basis for determining the success of the instructional actions.

Qualitative analysis was applied to observation and interview data to provide an in-depth description of the learning process. This analysis focused on children's level of engagement, the dynamics of interaction during experimental activities, and the effectiveness of the teacher's role as a learning facilitator. Qualitative findings were used to support quantitative results and to inform reflection at the end of each learning cycle.

The success of the intervention was determined based on two main indicators: process and outcome. From a process perspective, learning was considered successful if at least 90% of the instructional stages were implemented as planned. From an outcome perspective, the intervention was deemed successful if at least 85% of children achieved the categories of developed as expected and very well-developed at the class level.

RESULTS

Teachers' Teaching Activities in Cycle I and Cycle II

The implementation of instructional actions in cycle I was conducted across three meetings on March 10, 11, and 12, 2025. Each meeting followed a structured sequence of opening, core, and closing activities to introduce the color experiment method gradually. Cycle II was also implemented in three meetings, held on March 17 and 18, 2025, with a primary focus on refining instructional strategies based on reflections from cycle I.

Observation results indicate that teachers' teaching activities in cycle I had not yet reached an optimal level. Of the 12 observed teaching activity indicators, only 7 were implemented effectively, resulting in an achievement rate of 58.33%. Several components were not consistently implemented, including perceptual activities, the provision of motivation and reinforcement, and question-and-answer sessions aimed at exploring children's understanding. These findings suggest that teachers were still in the adaptation phase when applying the color experiment method.

Improvements were implemented in cycle II by emphasizing clearer instructions, increasing teacher–child interaction, and strengthening reflective feedback following experimental activities. Observation results demonstrated a substantial improvement, with 11 of the 12 teaching activity indicators successfully implemented. Consequently, the achievement rate increased to 91.66%. This improvement indicates that teachers were able to manage learning activities in a more structured and responsive manner, aligned with children's learning needs. A comparison of teachers' teaching activities across both cycles is presented in Figure 2.

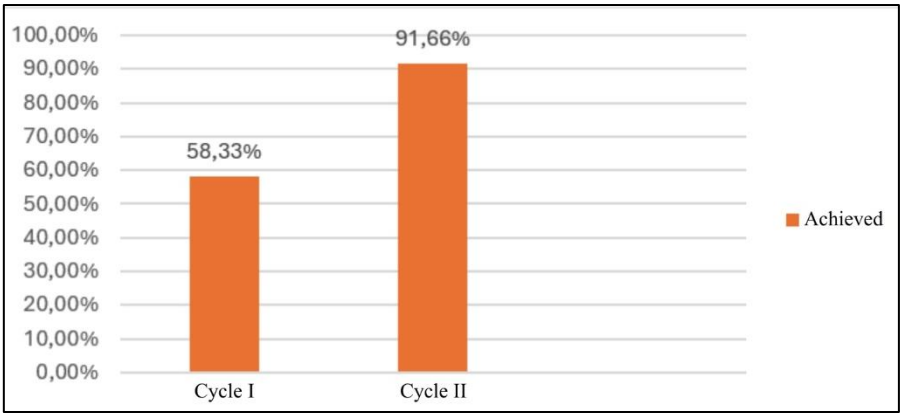

Figure 2. Comparison of Teachers' Teaching Activities in Cycle I and Cycle II

Figure 2 illustrates the increase in the percentage of teaching activity implementation from cycle I to cycle II following improvements in instructional strategies. This finding is supported by interview data with classroom teachers, one of whom stated, *"In the first cycle, I was still adjusting how I explained the activities and supported the children. After reflection, I focused more on giving simple instructions and providing closer guidance during the experiments".* This statement highlights the role of reflective practice in enhancing instructional quality.

Development of Children's Cognitive Abilities in Cycle I

The results of the assessment of children's cognitive abilities in cycle I are presented in Table 2. The data indicate that, at the class level, most children had reached the categories of developed as expected and very well developed. Of the 14 children, 7 children (50%) were categorized as developed as expected, while 4 children (29%) achieved the developed as expected category. However, 3 children (21.42%) remained in the beginning to develop category.

Table 2. Distribution of Children's Classical Achievement Scores in Cycle I

Category	Number of Children	Percentage
very well developed	4	95%-100%
developed as expected	7	85%-94%
beginning to develop	3	75%-84%
not yet developed	0	<75%
Total	**14**	

Findings from Table 2 demonstrate that implementing the color experiment method in cycle I had a positive effect on children's cognitive abilities, particularly in recognizing colors and following simple experimental procedures. Nevertheless, the overall class achievement had not yet met the predetermined success criterion, which required at least 85% of children to reach the developed as expected and very well-developed categories. Therefore, instructional improvements were necessary in the subsequent cycle.

Observational data further revealed that some children remained passive and hesitant when communicating experimental results. One teacher explained during an interview, *"Some children were willing to try the activity, but they were still reluctant to explain what they observed. They needed more examples and encouragement".* These findings informed the planning of instructional improvements in cycle II.

Children's Learning Activities and Cognitive Abilities in Cycle II

The refinement of instructional strategies in cycle II had a direct and positive impact on children's learning activities. Observation results showed a significant increase in children's engagement during experimental tasks. The achievement rate of children's learning activities increased from 58.33% in cycle I to 91.66% in cycle II. Children demonstrated greater involvement in color-mixing activities, actively observed changes, and responded more frequently to teacher questions. A comparison of children's learning activities across cycles is shown in Figure 3.

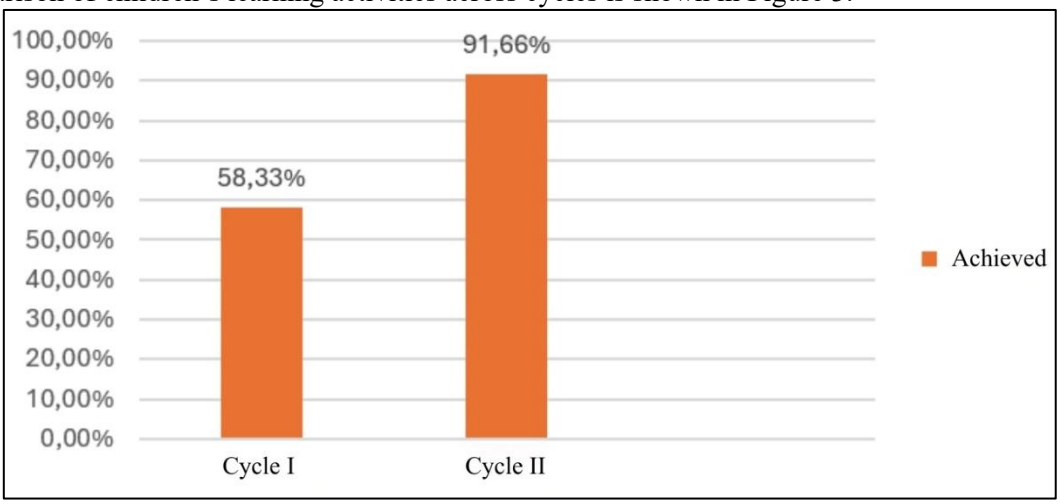

Figure 3. Comparison of Children's Learning Activities in Cycle I and Cycle II

Figure 3 illustrates the increased level of children's engagement in color experiment activities following instructional improvements in cycle II. The results of the cognitive ability assessment in cycle II are presented in Table 3. The data show that 6 children (50%) reached the very well-developed category, while 7 children (43%) achieved the developed as expected category. Only 1 child (7.14%) remained in the beginning to develop category, and no children were classified as not yet developed. At the class level, cognitive achievement reached 92.85%, exceeding the established success indicators.

Table 3. Distribution of Children's Cognitive Ability Achievement in Cycle II

Category	Number of Children	Percentage
very well developed	6	95%-100%
developed as expected	7	85%-94%
beginning to develop	1	75%-84%
not yet developed	0	<75%
Total	**14**	

Although most children demonstrated substantial improvement, one child remained in the beginning to develop category. Observation and interview findings indicated that this child experienced difficulties in maintaining focus and engaging in two-way communication. A teacher noted, *"This child tends to be quiet and easily distracted, so he requires more intensive guidance compared to other children"*. These findings emphasize the importance of considering individual differences when implementing experiment-based learning approaches.

Comparison of Children's Learning Outcomes across Observation Phases

A comparison of children's learning outcomes from the initial observation through cycle II reveals a consistent pattern of improvement, as shown in Figure 4. Figure 4 shows that at the time of the initial observation, the class-level cognitive achievement was only 42.85%. Following the implementation of the color experiment method in cycle I, this figure increased to 78.57%. The most substantial improvement occurred in cycle II, where class-level achievement reached 92.85%.

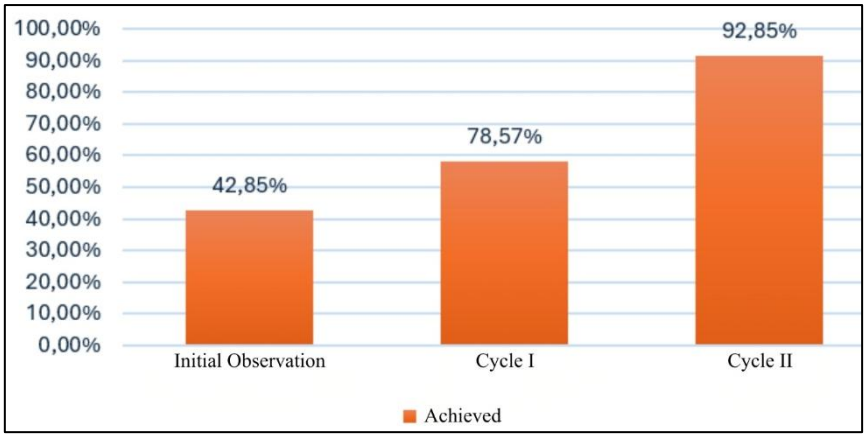

Figure 4. Overview of Changes in Children's Learning Outcomes

These results indicate that improvements in instructional quality, clearer explanations, more engaging learning media, and intensified teacher support contributed significantly to the development of children's cognitive abilities. Children became more active, focused, and enthusiastic during learning activities. In addition to recognizing colors, they were able to observe changes and communicate experimental outcomes with greater confidence.

Overall, the findings demonstrate that the color experiment method effectively enhanced the cognitive abilities of children aged 5–6 years. The achievement levels attained in cycle II exceeded the predetermined success criteria, indicating that the intervention was successful. These results confirm that hands-on, experiential learning is an effective strategy for optimizing cognitive development in early childhood.

DISCUSSION

This study aimed to examine improvements in the cognitive abilities of children aged 5–6 years through the application of the color experiment method. The findings demonstrate that this method was effective in gradually and sustainably enhancing children's cognitive abilities, as reflected in the increase in class-level achievement from the initial observation to cycle II. These results confirm that learning from direct experience plays a strategic role in optimizing cognitive development during early childhood, particularly during the golden period.

The significant improvement observed in cycle II is consistent with the developmental characteristics of children aged 5–6 years, who are transitioning toward more organized thinking skills. At this stage, children begin to classify objects, understand simple cause-and-effect relationships, and use symbols to represent experiences (Borst & Houdé, 2022; Mu'min, 2013; Rabindran & Madanagopal, 2020). The color experiment activities implemented in this study provided concrete, observable experiences that met these developmental needs. Through direct manipulation and observation, children actively constructed their understanding of concepts.

The findings further reinforce the view that early childhood cognitive development is strongly influenced by the quality of stimulation provided in the learning environment. In line with Irfani et al. (2025), interactive stimulation involving exploration and experimentation was shown to support the development of thinking skills, memory, and problem-solving abilities. In this study, cognitive improvement was not limited to children's mastery of color concepts. It was also evident in their ability to observe changes, draw simple conclusions, and communicate experimental outcomes. This indicates that the color-experiment method contributes more comprehensively to cognitive development.

Improvements in teachers' instructional practices from cycle I to cycle II played a critical role in supporting learning success. During cycle I, limitations in perception activities, motivation, and reflective interaction reduced children's engagement. Following reflection and instructional refinement in cycle II, teaching practices improved substantially. These findings align with constructivist perspectives that emphasize the teacher's role as a facilitator who designs learning environments rich in stimulation and encourages active participation (Belolutskaya et al., 2022; Gautam & Agarwal,

2023). Therefore, the effectiveness of the experimental method is closely linked to teachers' pedagogical competence in managing learning processes.

From a constructivist perspective, the observed improvement in children's cognitive abilities highlights children's active role in constructing knowledge. Color-mixing activities enabled children to learn through play, exploration, and social interaction, as emphasized by Wibowo et al. (2025) and Zajda (2021). Rather than passively receiving information, children were directly involved in discovering concepts through hands-on experiences. As a result, learning became more meaningful and aligned with the characteristics of early childhood learning.

The results of this study also support previous research indicating that experimental methods are effective in enhancing cognitive development in early childhood (Fatimah, 2024; Hudaifah & Mashudi, 2024). However, this study extends earlier findings by demonstrating that color experiments not only improve color recognition but also foster logical thinking and simple problem-solving skills. In doing so, this study addresses limitations of earlier research that primarily focused on mastery of the color concept (Fajriani & Liana, 2020; Fitri, 2021).

An important finding of this study is the improvement in children's ability to communicate experimental results, which reflects integration between cognitive and language development. Consistent with Afifa et al. (2024) and Hidayat et al. (2023), children's ability to explain their observations indicates the emergence of symbolic and reflective thinking. Although children continued to use simple language, their increased willingness to describe color changes suggests that the color experiment method supports early scientific communication skills.

Despite the overall improvement, one child remained in the beginning to develop category in cycle II. This finding underscores that cognitive development in early childhood is individual and influenced by internal factors, such as communication ability and attention regulation. Differences in individual responsiveness to learning stimulation should therefore be considered when implementing experimental learning methods. Early childhood learning must remain flexible and adaptable to ensure that each child receives appropriate support tailored to their unique characteristics.

From a broader early childhood education perspective, the findings highlight the importance of systematically and continuously designed learning experiences. As noted by Hasyim (2015) and Wahyuni et al. (2025), early childhood education aims not only to develop early academic skills but also to build integrated cognitive, social, and emotional foundations. The color experiment method demonstrated strong potential as an innovative and contextually applicable learning strategy, including in settings with limited learning resources.

Theoretically, this study reinforces the relevance of cognitive development theory and constructivist approaches in early childhood learning practices. Empirically, it provides evidence that a systematically designed color experiment method can significantly enhance the cognitive abilities of children aged 5–6 years. These findings suggest that experiment-based learning represents a strategic alternative for improving the quality of early childhood education, particularly in fostering foundational thinking skills.

The implications of this study indicate that the color experiment method has strong potential for broader integration into early childhood education practices. Implementing this method requires teachers to move beyond the role of content transmitters and act as facilitators who design concrete, meaningful, and child-centered learning experiences. The findings show that experiment-based learning enhances children's active engagement and supports comprehensive cognitive development, including logical thinking, simple problem-solving, and communication of observational results. Practically, early childhood education institutions should encourage the use of simple, science-based exploratory learning strategies that remain effective even in contexts with limited resources. Theoretically, the results further strengthen the relevance of constructivist and experiential learning approaches within early childhood education.

CONCLUSION

This study concludes that the color experiment method is effective in improving the cognitive abilities of children aged 5–6 years. The improvement is evidenced by a gradual increase in children's cognitive achievement from the initial observation to cycle II, with most children reaching the developed as expected and very well-developed categories at the class level. The color experiment

method actively engages children in the learning process through direct experience, thereby supporting the development of logical thinking, understanding of cause-and-effect relationships, and the ability to communicate observational outcomes.

In addition to improving learning outcomes, the color experiment method also enhances the quality of the learning process. Both teachers' instructional activities and children's learning engagement showed significant improvement following reflective practice and instructional refinement. Teachers functioned more effectively as facilitators, while children demonstrated greater enthusiasm, focus, and participation during learning activities. These findings confirm that hands-on, experiential learning represents a relevant and effective strategy in early childhood education.

This study has several limitations, including the relatively small number of participants, the research context limited to a single institution, and the short implementation period, which did not allow for long-term observation. Furthermore, the assessment of cognitive abilities focused primarily on indicators related to color experiment activities. Therefore, future research is recommended to involve larger and more diverse samples, be conducted over a longer period, and employ more comprehensive assessment instruments. Further studies may also explore the application of color experiment methods to other developmental domains, such as language and social-emotional development, to obtain a more comprehensive understanding of their impact.

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