

Enhancing Early Childhood Cognitive Development through Experiential Science Learning: The Rainbow Water Approach

Firdausi Nuzula Apriliyana¹, Ika Irayana²

¹ Universitas PGRI Ronggolawe Tuban, Indonesia; elnuzula23@gmail.com

² UIN Antasari Banjarmasin, Indonesia; ika.irayana@uin-antasari.ac.id

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ABSTRACT

This study examines the implementation of Rainbow Water science learning media and its impact on the cognitive development of children aged 3–4 years at KB Al Azhar Gresik. Using a qualitative descriptive design with a naturalistic approach, data were collected through participatory observation, in-depth interviews, and documentation involving the principal, teachers, and students. Data analysis followed the Miles and Huberman model, including data collection, reduction, display, and conclusion drawing, while validity was ensured through triangulation. The findings indicate that Rainbow Water serves as an effective experiential learning medium that stimulates children's cognitive development through direct experimentation and interaction. The implementation involves structured stages, including theme determination, preparation of materials, guided activities, and evaluation. Children showed progressive cognitive improvement, particularly in recognizing colors, responding to questions, and demonstrating better attention and behavioral control. Additionally, the activity fosters basic scientific thinking skills such as observing, predicting, and understanding cause-and-effect relationships. The study also reveals that children's enthusiasm supports learning engagement, although challenges in self-regulation remain. Supporting factors include teacher collaboration and adequate facilities. Overall, this study reinforces constructivist theory and highlights the importance of innovative, experience-based learning in optimizing early childhood cognitive development.

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Corresponding Author:

Firdausi Nuzula Apriliyana

Universitas PGRI Ronggolawe Tuban, Indonesia; elnuzula23@gmail.com

INTRODUCTION

In every human life, education is an essential need (Kleebbua & Siriparp, 2016; Mariyono, 2024). In general, education is an effort made by individuals to develop their potential and talents through the learning process. Through this process, individuals gain knowledge and begin to recognize their own abilities so that they can optimize them. Therefore, education should be provided from an early age (Rohwer, 1971). Montessori argued that education must begin from birth. The first year of life is a highly formative and crucial period, both physically and mentally. Infants possess active minds,

meaning they are not passive beings who merely wait for instructions from others. Maria Montessori also believed that in the early years of life, children experience sensitive periods, during which they are naturally ready to develop according to their inherent potential (Catherine et al., 2019; Politi, 2023).

Based on Law Number 20 of 2003, early childhood education is an effort to stimulate growth and development in children from birth to six years of age, both physically and spiritually, so that they are prepared to enter the next level of education. During this period, children's growth and development occur very rapidly (Correia et al., 2019). At this stage, the brain can absorb information from the surrounding environment more quickly (Haq & Roesminingsih, 2024). The purpose of education is to support children's developmental processes so they can achieve their abilities according to their developmental stage. Additionally, early childhood education helps children develop social skills within their environment. In the family setting, children are the responsibility of parents, while in the school environment, they are the responsibility of teachers. Therefore, collaboration between parents and teachers is essential to support optimal child development (Siraj et al., 2019).

Referring to the Regulation of the Minister of Education and Culture Number 37 of 2014, early childhood education is designed to stimulate and optimize various aspects of development. There are six developmental aspects that must be nurtured by early childhood educators, namely religious and moral values, cognitive, social-emotional, language, physical-motor, and artistic development. Zaini stated that learning for young children should be carried out through play, as playing is a fundamental right of every child (Gea et al., 2025; Mayra et al., 2022). Children enjoy playing because it allows them to engage in activities that bring them happiness (Yulianis et al., 2025). Through play, children can explore and learn freely, which leads to the acquisition of new knowledge. Playing also supports the development of children's physical, intellectual, linguistic, and behavioral potential. Play activities can take place both inside and outside the classroom.

The term cognitive originates from the word "cognition," which means knowing. Cognition broadly refers to the acquisition, organization, and use of knowledge. According to the Indonesian Dictionary (KBBI), cognitive relates to or involves cognition based on factual and empirical knowledge. Yusuf explained that cognitive ability refers to a child's capacity to think more complexly, reason, and solve problems. The development of cognitive abilities helps children master broader general knowledge, enabling them to function effectively in everyday social life. Cognitive or intellectual ability is the capacity to connect events (Allaire & Marsiske, 1999), evaluate situations, and make judgments about the surrounding environment. Cognitive development illustrates how children think. Piaget, as cited by Slamet Suyanto, argued that all children go through the same stages of development: sensorimotor, preoperational, concrete operational, and formal operational stages. However, children at early stages tend to think egocentrically and are not yet able to fully accept others' perspectives (Birney et al., 2005).

Playgroups (Kelompok Bermain/KB) are non-formal educational institutions within the early childhood education level, typically serving children aged 3–4 years. KB Al Azhar Gresik is an institution located in Gresik. At the age of 3–4 years, children experience rapid growth and development. They are born with a sense of wonder and a strong curiosity to explore their surroundings. Therefore, children's knowledge is not only obtained through direct interaction but also through thinking processes involving changes and experimentation to understand the natural world. Observations show that learning activities for children are often monotonous, as they tend to focus primarily on books. Meanwhile, teachers are responsible for creating engaging and enjoyable learning experiences. Teachers should implement learning through play, meaning that activities should be fun and free from pressure. To make learning more interesting, teachers need to modify instructional approaches by introducing new learning media. For example, science-based learning media can be used to enhance children's cognitive abilities.

According to Guillory, (2010), the term "media" originates from the Latin word *medius*, which means intermediary or medium. Fauziddin added that media can also take the form of humans, events, or occurrences that provide learning experiences and knowledge. According to Widodo & Wahyudin,

*2018), learning media can create concrete learning situations, helping teachers deliver material so that students can understand it more easily. Thus, effective and varied media contribute to the effectiveness of the learning process (Lubis et al., 2023). The National Education Association (NEA) defines media as tools that can be used, seen, heard, or read in learning activities and that influence the effectiveness of instructional programs. Puspitarini & Hanif, (2019) stated that learning media are all tools that can be used to convey messages in the learning process in order to stimulate children's attention, interest, feelings, and thoughts to achieve learning objectives.

Science is a field of knowledge related to natural phenomena, explored through scientific processes. It is also closely related to ways of thinking and obtaining information based on objective facts and truth. Essentially, science encompasses three main components that represent it comprehensively: science as a body of knowledge, science as a process, and science as a set of values. First, science as a body of knowledge refers to theories, principles, and facts that have been studied (Barnes, 2013). Second, science as a process indicates that these theories, principles, and facts are obtained through scientific activities such as observation, experimentation, and systematic conclusion-making.

One characteristic of early childhood is their strong curiosity. They tend to be eager to learn about their surroundings. This curiosity should be utilized by parents, teachers, and others around them to guide children in exploring information they wish to understand. In science learning, this curiosity becomes a valuable asset for teachers to direct children's learning activities effectively. According to Mursi, there are several benefits of science learning (Mulyeni et al., 2019; Sowmya & Rani, 2025): (1) children are able to seek knowledge through observation of their surroundings, (2) children can communicate the knowledge they acquire, (3) children can optimize their thinking skills, and (4) children can develop scientific attitudes and values. Therefore, science learning provides both experience and knowledge for children. However, children still require guidance from adults to develop their understanding of scientific processes, conceptual knowledge, and how to apply them.

Based on the background described above, the researcher is interested in conducting a study presented in a scientific work entitled "The Implementation of Rainbow Water Science Learning Media on the Cognitive Development of Children Aged 3–4 Years at KB Al Azhar Gresik." Based on the background described above, the researcher is interested in conducting a study presented in a scientific work entitled "The Implementation of Rainbow Water Science Learning Media on the Cognitive Development of Children Aged 3–4 Years at KB Al Azhar Gresik." The objectives of this study are to describe the implementation of Rainbow Water science learning media for children aged 3–4 years at KB Al Azhar Gresik, and to examine the cognitive development of children aged 3–4 years through the implementation of this learning media at KB Al Azhar Gresik.

METHODS

This study employs a qualitative research design with a descriptive approach based on the type of data used. According to Bogdan and Taylor, qualitative research produces data in the form of spoken words (Arif, 2023, 2025), written expressions, and observable human behavior within a particular context. This method is often referred to as a post-positivistic approach, as it is grounded in post-positivism philosophy, which views reality as something that can be classified, observed, measured, and understood through cause-and-effect relationships. In addition, qualitative research is also known as a naturalistic method because it is conducted in natural settings without manipulation of variables. Historically, this method is closely associated with ethnographic research, which originated in cultural anthropology. Koentjaraningrat explains that qualitative research is part of the humanities that systematically collects, analyzes, and interprets facts about human behavior and social phenomena to generate knowledge. Similarly, Kirk and Miller define qualitative research as a tradition in social science that depends on human observation in both context and terminology. From these perspectives,

it can be concluded that qualitative research is a method that gathers data naturally to interpret phenomena or events as they occur in real-life situations (Leavy, 2020).

Qualitative research has several key characteristics as proposed by Bogdan (Jacob, 1989). First, it is naturalistic, meaning that data are obtained directly from real-life situations, and the researcher acts as the primary instrument. Second, it is descriptive, emphasizing narrative explanations rather than numerical data, with findings presented in words or detailed descriptions. Third, it focuses on processes rather than outcomes, as researchers aim to understand how and why a phenomenon occurs rather than merely measuring the results. Fourth, it is inductive, meaning that data collection is not driven by pre-existing hypotheses but instead allows patterns and conclusions to emerge from the data itself (Bennett, 2006). Fifth, it emphasizes meaning, where the interpretation of events is based on the perspectives of the participants involved. Through this qualitative approach, the researcher seeks to uncover factual insights regarding the implementation of Rainbow Water science learning media in supporting the cognitive development of children aged 3–4 years at KB Al Azhar Gresik.

This research is categorized as field research, where data are collected directly through participatory observation. In this approach, the researcher is actively involved in the activities being observed to obtain richer and more comprehensive data regarding children's behavior and learning processes. The research is conducted at KB Al Azhar Gresik as the primary site. The descriptive nature of this study aims to provide a clear and factual depiction of the phenomena being studied, ensuring that the data collected are based on real conditions rather than subjective opinions. Data sources in this study are divided into primary and secondary sources. Primary data are obtained directly from participants who are responsible for providing or generating information, while secondary data are derived from literature sources such as books, documents, and other relevant references. Data collection techniques include observation, interviews, and documentation. Observation allows researchers to gather firsthand information through the senses, interviews facilitate in-depth understanding through direct communication, and documentation provides supporting evidence such as records, photos, and institutional archives (Chen, 2015).

In terms of instruments, the researcher serves as the main instrument in qualitative research, supported by observation sheets, interview guidelines, and documentation records. Observation sheets are used to guide the researcher in identifying specific aspects to be observed, while interview guidelines help structure conversations to obtain relevant and in-depth information. Documentation tools are utilized to collect written or visual data that support the research findings. Data analysis in this study follows the model proposed by Miles and Huberman, which consists of four main steps: data collection, data reduction, data display, and conclusion drawing or verification. Data collection involves gathering information from interviews, observations, and documents. Data reduction is the process of selecting and simplifying data to focus on relevant information. Data display presents the data in narrative or visual forms to facilitate understanding. Finally, conclusions are drawn and verified based on the consistency and strength of the evidence collected, ensuring that the findings are credible and well-supported (Arif et al., 2021; Dodgson, 2017).

To ensure the validity of the data, this study applies credibility testing through several techniques, including prolonged observation, increased persistence, and triangulation. Prolonged observation allows the researcher to revisit the field, build trust with participants, and ensure that no important information is overlooked. Increased persistence involves conducting observations carefully and continuously to obtain accurate and systematic data. Triangulation is carried out in three forms: source triangulation, technique triangulation, and time triangulation. Source triangulation compares data obtained from different participants, technique triangulation verifies data using different methods such as interviews, observations, and documentation, and time triangulation examines data consistency across different situations and times. Through these strategies, the researcher ensures that the findings regarding the implementation of Rainbow Water science learning media on the cognitive development of children aged 3–4 years at KB Al Azhar Gresik are valid, reliable, and reflective of actual conditions in the field.

FINDINGS AND DISCUSSION

Based on the results of the research that has been conducted, the researcher obtained several findings regarding the Implementation of Rainbow Water Science Learning Media on the Cognitive Development of Children Aged 3–4 Years at KB Al Azhar Gresik. In this study, the researcher used three methods, namely observation, interviews, and documentation to collect data at KB Al Azhar Gresik. Furthermore, the researcher used data analysis techniques to obtain more in-depth research results. The data analysis technique used is descriptive qualitative by analyzing data obtained from observations, interviews, and documentation conducted at KB Al Azhar.

From the data obtained by the researcher, an analysis was then carried out in accordance with the research focus. All data obtained by the researcher came from Mrs. DP as the Principal of KB Al Azhar Gresik and Mrs. LM as the school operator as well as the homeroom teacher of Group A, along with teachers at KB Al Azhar Gresik who supported the implementation of this research.

Data Presentation of Research Results

The following are the data from the research results that have been summarized according to the research focus, which will be described by the researcher as follows: Based on interviews conducted by the researcher with the principal of KB Al Azhar Gresik, the following data were obtained:

Rainbow Water Science Activities

Rainbow Water is a skill in the form of science activity using water and food coloring that are mixed to produce rainbow colors. This activity is directly related to natural phenomena that occur around children, one of which is the rainbow. Through this activity, children's curiosity increases. Regarding the Rainbow Water science activity in children's cognitive development, Mrs. DP explained that:

“The activity carried out to develop the cognitive abilities of children aged 3–4 years is the Rainbow Water science activity. This activity is different from usual activities that focus on books; it is more varied and can develop children's cognitive skills such as recognizing colors.”

Meanwhile, according to Mrs. LM as the homeroom teacher of Group A:

“The activity carried out to develop children's cognitive abilities is the Rainbow Water science activity, where this activity is done so that children do not feel bored with activities that focus on books.”

The Rainbow Water activity becomes one of the choices in science activities for children aged 3–4 years because the media used is different from commonly used media. Based on interviews conveyed by the principal and the homeroom teacher of Group A regarding the cognitive development of children aged 3–4 years at KB Al Azhar Gresik, the researcher can explain the steps in implementing the Rainbow Water science activity as follows:

Determining the theme to be achieved

Before learning begins, the teacher determines the theme to be used so that the activity can run optimally. The theme is chosen according to the activity to be carried out. From the observation results at KB Al Azhar Gresik, before conducting activities, the teacher first prepares or designs a daily learning plan (RPPH) according to the theme to facilitate the learning process.

Preparing the media to be used

The next step in the Rainbow Water science activity is preparing the tools and materials needed. The teacher prepares tools and materials such as glasses, food coloring (red, yellow, green), salt, spoons, water, and also pictures of a rainbow. With these tools and materials, the teacher can more easily explain the activity to children.

Based on the interview results, Mrs. LM as the homeroom teacher of Group A stated:

“The media used in the Rainbow Water science activity are water, glasses, salt, spoons, and of course food coloring. Here I use three food colorings, namely red, yellow, and green. Then I also prepare a picture of a rainbow to explain what activity the children will do.”

From the explanation of Mrs. LM it can be concluded that in every activity the teacher prepares the tools and materials that support the learning process, making it easier to explain to children.

Explaining the Rainbow Water science activity

At the next stage, before giving assignments, the teacher explains the Rainbow Water science activity to children so that they understand the steps they will carry out. The following is the interview result from Mrs. LM as the homeroom teacher of Group A:

“Before the children’s learning activities begin, I first prepare the tools and materials to be used so that children can recognize and know what tools and materials are needed. Then after introducing them, I also ask questions such as: what tools and materials will we use, what colors will we use, and how to make Rainbow Water. After that, I continue by practicing together with the children.”

Based on this explanation, it can be concluded that teachers at KB Al Azhar Gresik try to maximize activities by explaining the Rainbow Water science activity and guiding children throughout the process.

Evaluation

The final step in the Rainbow Water science activity is evaluation. Evaluation is a repetition of the material that has been delivered by the teacher to the children. In this case, the teacher invites children to recall what activities they have done. Evaluation can be carried out through question and answer sessions about the activity and their feelings after participating in the Rainbow Water science activity. From the explanation above, it can be concluded that teachers at KB Al Azhar Gresik have maximized the final evaluation process in learning activities.

Cognitive Development

Cognitive comes from the word cognition which means knowing. In a broad sense, it refers to the acquisition, organization, and use of knowledge. It can also be interpreted as the ability to learn new skills, understand what happens around them, use memory, and solve simple problems. Cognitive development in early childhood refers to children’s ability to understand things. However, each child has different cognitive development because the process involves many stages such as understanding information, problem-solving, and decision-making. To understand children’s cognitive development, teachers at KB Al Azhar Gresik stimulate children during the learning process. The principal stated:

“The cognitive development of children at KB Al Azhar Gresik has developed well, although there are some children whose cognitive development is not yet optimal. Considering that each child develops differently, activities are needed to train children’s cognitive development.”

Meanwhile, the homeroom teacher of Group A stated:

“Indeed, the cognitive development of children at KB Al Azhar Gresik varies. For example, some children can already recognize colors well, while others still cannot distinguish colors. Therefore, children must be given activities that can optimize their cognitive development.”

Mrs. LM also explained that every day children are encouraged to develop their cognitive skills through active interaction, such as recognizing objects around them, observing and exploring their environment, asking questions, and engaging in interesting activities that support cognitive development.

Supporting and Inhibiting Factors in Rainbow Water Science Activities

There are several factors that influence children’s cognitive development in the Rainbow Water science activity, namely supporting and inhibiting factors. The principal stated:

“The supporting factor for the Rainbow Water science activity in developing children's cognitive abilities is the collaboration between the principal and teachers, where the school facilitates the activity.”

Meanwhile, the homeroom teacher of Group A stated:

“The supporting factors in this Rainbow Water science activity are the high enthusiasm of the children and the school facilities that support the activity.”

From these interview results, it can be concluded that teacher support and school facilities are important factors in supporting children's activities. The inhibiting factor in the Rainbow Water science activity is children's impatience due to their high enthusiasm. As stated:

“The inhibiting factor in the Rainbow Water science activity is the lack of patience among children due to their high enthusiasm.”

Results of Observation

Based on the observations conducted by the researcher, KB Al Azhar Gresik is a non-formal early childhood education institution. The researcher conducted the study in the playgroup for children aged 3–4 years. The following are the results of observations through the Rainbow Water science learning media on children's cognitive development. During the Rainbow Water activity, children showed high enthusiasm. This was evident when the teacher prepared the tools and materials. They expressed enthusiasm by asking questions about the activity to be carried out. When the teacher explained each material and tool, the children were able to answer questions about their shapes, colors, tastes, and other characteristics. Through this interaction, children developed confidence and language skills. Before conducting the Rainbow Water science activity, the teacher explained the steps clearly. The teacher guided children to be careful so that the food coloring would not spill on their clothes. In this activity, children and teachers worked together, creating a collaborative and engaging learning experience.

Table 1 : Summary of Research Analysis on Rainbow Water Science Learning and Its Impact on Early Childhood Cognitive Development

Variable	Indicator	Key Findings
Learning Media	Rainbow Water	Experiment-based media using water and colors increases children's learning interest
Planning	Theme & Lesson Plan (RPPH)	Teachers design learning systematically before the activity
Implementation	Explanation & Practice	Children learn through direct experimentation (active learning)
Evaluation	Question & Answer	Children recall and reflect on the activities conducted
Cognitive Development	Color recognition	Some children are able to recognize colors, others are still developing
	Concept understanding	Children begin to understand color mixing
	Language skills	Children actively ask and answer questions
	Attention	Children show better focus during activities
Children's Behavior	Enthusiasm	Children are highly engaged and interested
	Self-regulation	Children still have difficulty waiting for their turn
Supporting Factors	Facilities & teachers	School environment and teacher collaboration support learning

Inhibiting Factors	Patience	High enthusiasm but low self-control among children
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In conclusion, the findings of this study demonstrate that the implementation of Rainbow Water science learning at KB Al Azhar Gresik serves as an effective and meaningful pedagogical strategy in enhancing early childhood cognitive development. Through structured stages ranging from planning, implementation, to evaluation this experiment-based learning approach successfully engages children in active, contextual, and experiential learning processes. The results reveal that children not only develop basic cognitive skills such as color recognition and conceptual understanding, but also show improvements in language, attention, and early scientific thinking abilities.

Moreover, the success of this learning activity is strongly influenced by the synergistic interaction between supporting factors, including teacher competence, institutional facilities, and children's learning enthusiasm. However, challenges related to children's self-regulation highlight the need for adaptive classroom management strategies. Therefore, this study implies that effective early childhood education should prioritize hands-on, inquiry-based learning supported by competent educators and conducive learning environments. Ultimately, the Rainbow Water activity reflects the broader principle that meaningful learning experiences play a crucial role in fostering holistic child development, particularly in the cognitive domain.

DISCUSSION

The results of the study indicate that the implementation of the Rainbow Water science learning media at KB Al Azhar Gresik does not merely function as a regular learning activity, but also as a pedagogical strategy capable of significantly stimulating children's cognitive development (Dewanti, 2022; Jacob, 1989; Khan & Singh, 2015). These findings demonstrate that experiment-based learning activities possess strong potential in constructing children's conceptual understanding through direct experience (Rohimat, 2022). This suggests that concrete and contextual learning approaches are more effective than conventional, book-centered methods. At the initial stage of implementation, it was found that some children had not yet shown optimal cognitive development (Abdulhameed & Rashid, 2022; Keil, 1981), particularly in recognizing colors and controlling behavior such as waiting for their turn. Theoretically, this condition aligns with the characteristics of children aged 3–4 years who are in the preoperational stage, where symbolic abilities begin to develop but are still limited in terms of self-regulation and logical thinking (Silva et al., 2024). Therefore, these limitations should not be viewed as a failure of learning, but rather as part of a natural developmental process that requires continuous stimulation (Pangestu, 2025; Wang et al., 2024).

The changes observed in the second and third meetings indicate a progressive developmental pattern (Beroukhim et al., 2022). Children began to identify colors, respond to questions, and show improvements in attention and discipline. This confirms that learning conducted repeatedly and consistently can strengthen children's cognitive pathways (Cherukunnath & Singh, 2022), particularly in aspects of memory, association, and basic conceptual understanding. Substantively, the Rainbow Water activity does not only train cognitive abilities in a narrow sense (such as recognizing colors), but also involves basic scientific thinking processes (Brunet et al., 2023). Children are indirectly trained to observe, predict, and understand cause-and-effect relationships. These processes form the foundation of scientific thinking, which is essential for long-term intellectual development (Habeeb et al., 2024; Zahrah & Winarti, 2024).

Furthermore, children's active involvement in experimental activities reflects a shift from passive learning to active learning (Salway et al., 2022). Children are no longer merely recipients of information but become active agents who construct their own knowledge. From a constructivist perspective (Vella-Brodrick & Gilowska, 2022), this indicates that children's knowledge is built through interaction with their environment rather than being transmitted one-way from the teacher. The interview results with the principal and the classroom teacher reinforce the observational findings that Rainbow Water media can enhance children's learning motivation. The high level of enthusiasm shown

by children indicates that enjoyable learning has a positive correlation with cognitive engagement. However, this high enthusiasm also presents challenges in classroom management, particularly in terms of children's self-control.

From a pedagogical perspective, this condition highlights the crucial role of teachers in managing classroom dynamics (Okokoyo Isabella Ezinwa, 2024; Zhou, 2025). Teachers are not only responsible for delivering content but must also be able to channel children's energy and enthusiasm into a conducive learning environment. This confirms that the success of learning media implementation depends not only on the media itself but also on the pedagogical competence of the teacher. Moreover, the success of this activity is also supported by institutional factors, such as the availability of facilities and collaboration among educators (Desta et al., 2023; Raheef, 2024). A supportive learning environment enables experimental activities to be carried out optimally. This indicates that the implementation of innovative learning requires synergy between individual factors (teachers and students) and structural factors (school support) (Jafarov, 2023).

Theoretically, these findings strengthen the view that science learning in early childhood should not focus on abstract concept mastery, but rather on meaningful direct experiences. The Rainbow Water activity represents contextual science learning (Hsu, 2006), where children learn from simple phenomena that are closely related to their daily lives. In terms of cognitive development, this activity also contributes to the development of children's executive functions, such as the ability to focus, remember instructions, and complete tasks. Although these aspects were not explicitly measured, their indications can be seen from changes in children's behavior during the learning process (Lange & Pierce, 1992; Schneider et al., 2000).

The use of triangulation methods in this study strengthens the validity of the findings. The consistency between observation, interview, and documentation results indicates that the data obtained have a high level of credibility. This is important to ensure that the conclusions drawn accurately reflect real conditions in the field. However, the study also reveals certain limitations, particularly related to children's self-regulation, which is still developing. High enthusiasm that is not yet balanced with self-control becomes a challenge in implementing experimental activities (Andersson, 2012; Tanco et al., 2009). This opens opportunities for further research to explore more effective classroom management strategies in experiment-based learning contexts. Overall, the findings of this study demonstrate that Rainbow Water science learning media has strategic value in developing early childhood cognitive abilities. This activity not only provides knowledge but also shapes children's thinking patterns, scientific attitudes, and exploratory skills (Pell & Jarvis, 2001; Tolmie et al., 2016).

Thus, it can be concluded that simple experiment-based learning is a relevant and effective approach in early childhood education. Proper implementation, supported by competent teachers and a conducive environment (Sher & Inamullah, 2025), will result in meaningful and sustainable learning processes that support children's holistic development. The implication of these findings is the need for further development of innovative and contextual science-based learning media. In addition, teacher training in managing experiment-based learning is essential to improve the overall quality of early childhood education (Cadwell, 2003; Chambers et al., 2016; Hewett, 2001).

CONCLUSION

Based on the results of the study conducted at KB Al Azhar Gresik, it can be substantively concluded that the implementation of the Rainbow Water science learning media plays a strategic role in stimulating the cognitive development of children aged 3–4 years through a concrete, exploratory, and experience-based learning approach. This activity not only introduces basic concepts such as colors and simple natural phenomena, but also encourages children to observe, experiment, and actively construct their understanding of their surrounding environment. Empirically, children's cognitive development shows a positive trend, although there are variations in achievement levels among individuals due to differences in characteristics and developmental stages. Therefore, the use of

innovative science learning media such as Rainbow Water has proven to be effective in developing children's basic thinking skills, while also emphasizing the importance of adaptive learning that aligns with the developmental needs of early childhood.

This study has theoretical implications that reinforce the constructivist perspective in early childhood education, suggesting that experience-based learning such as the Rainbow Water science activity is effective in gradually building children's knowledge and cognitive abilities through interaction with their environment. Practically, these findings contribute to teachers and early childhood education institutions by providing insights into developing more innovative, contextual, and enjoyable learning strategies to enhance children's engagement and cognitive development. However, this study has certain limitations, including its scope being limited to a single institution and a specific age group, as well as not examining other variables in depth, such as family background or differences in children's learning styles. Therefore, future research is recommended to expand the subjects and research settings, integrate quantitative approaches to measure effectiveness more objectively, and explore various other science learning media to gain a more comprehensive understanding of early childhood cognitive development.

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