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# Enhancing Critical Thinking and Curiosity in Early Childhood Through Inquiry-Based Science Learning

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| Article Info | Abstract |
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*Inquiry-based learning; Merdeka curriculum; Early childhood education; Science learning*

Early childhood is a critical period for cognitive, social, and emotional development, making it essential to foster critical thinking and curiosity in educational settings. This study explores the implementation of inquiry-based science learning for children aged 5-6 years within the Merdeka Curriculum framework to enhance these key developmental skills. Using a Research and Development (R&D) approach, the study designed, implemented, and evaluated inquiry-based science modules. Data were collected through a combination of qualitative and quantitative methods, including observations, interviews, and pre- and post-tests. The findings revealed that inquiry-based learning significantly improved children's critical thinking, curiosity, and understanding of scientific concepts, with pre-test scores improving from 46.29% to 80.57% in small group trials and from 48.38% to 80.76% in large group trials. While the approach increased student engagement and curiosity, teachers faced challenges in managing inquiry-based classrooms, indicating the need for further professional development. The study concludes that inquiry-based science learning aligns with the goals of the Merdeka Curriculum, promoting active learning and cognitive growth in early childhood education. Further support for teachers is recommended to ensure effective implementation and classroom management.

## 1. INTRODUCTION

Early childhood is a critical period in human development, characterized by rapid growth in various developmental domains, including cognitive, social, and emotional aspects. At this stage, fostering key skills such as critical thinking and curiosity is of paramount importance, as these abilities lay the foundation for lifelong learning and problem-solving. Critical thinking enables children to analyze, evaluate, and synthesize information, while curiosity drives them to explore new ideas and seek answers to questions about the world around them. Research shows that children who develop strong critical thinking skills early on tend to excel in academic settings and demonstrate higher levels of creativity and problem-solving abilities later in life (Facione, 2011). Similarly, curiosity is a significant predictor of a child's motivation to learn, influencing their willingness to engage in complex tasks and their persistence in overcoming challenges (Kidd & Hayden, 2015). Thus, fostering both critical thinking and curiosity during early childhood is essential to promote cognitive and intellectual growth.

Critical thinking and curiosity are essential for early childhood cognitive development, yet many educational programs fail to address these areas adequately. Traditional teaching methods, which rely on rote memorization and passive instruction, limit opportunities for self-directed learning and exploration, crucial for cultivating intrinsic motivation (Ryan & Deci, 2017). Research suggests that these methods hinder the development of problem-solving skills and critical thinking (Zurek, Torquati, & Acar, 2014; Liu et al., 2018). Despite the recognized benefits of early science education, its implementation remains challenging, particularly

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in Indonesia's Raudhatul Athfal (RA) schools (Figure 1). Educators often lack the necessary training and resources to teach science effectively, resulting in a continued reliance on traditional approaches such as lectures and worksheets (Hasbi et al., 2020). Surveys in Jagakarsa's RA schools reveal that while 28% have adopted the Merdeka Curriculum, 52% are still transitioning, and 20% have not yet implemented it. Teachers face challenges in designing engaging science activities due to limited understanding of scientific concepts, inadequate resources, and the predominantly classroom-based learning environment.

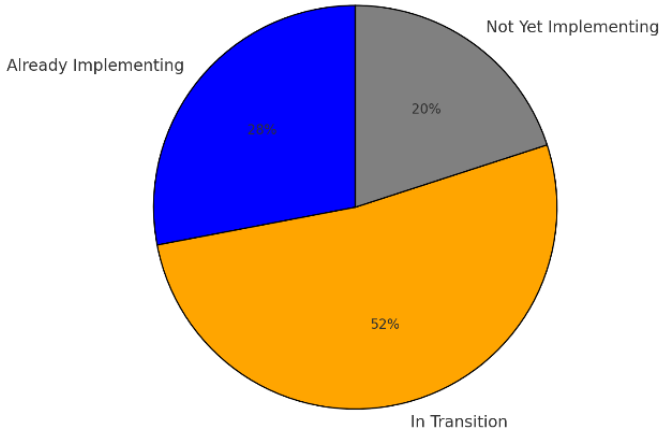

**Figure 1. Percentage of Merdeka Curriculum Implementation in School**

These issues are consistent with broader challenges in early childhood science education in Indonesia. Lack of suitable textbooks, resources, and insufficient teacher training are common barriers (Anderson et al., 2012; Greenfield, 2017). As a result, science teaching often remains teacher-centered, lacking the interactive, hands-on approach necessary for young children to develop a strong foundation in scientific inquiry. The introduction of the Merdeka Curriculum by the Indonesian Ministry of Education, Culture, Research, and Technology aims to address these challenges. It promotes a flexible, student-centered learning environment that focuses on competency-based education and character development, aligning with Ki Hajar Dewantara's philosophy of liberating education (Rahmi, 2022; Tarigan et al., 2022). This curriculum encourages interactive and meaningful learning experiences, particularly suited to early childhood education, where children are granted the freedom to explore, inquire, and interact with their environment.The transition to the Merdeka Curriculum presents opportunities to improve early childhood science education by encouraging student-centered and inquiry-based learning. However, its successful implementation depends on teachers adopting new teaching methods and gaining a deeper understanding of scientific concepts. This presents challenges for educators with limited science backgrounds or access to instructional resources.

One approach that has gained considerable attention is inquiry-based science learning, which encourages children to learn through hands-on experiences, experimentation, and problem-solving (Hakkarainen et al., 2013). This approach not only helps children grasp scientific concepts more deeply but also supports the development of cognitive skills by involving them in active learning. Inquiry-based learning aligns with Piaget's constructivist theory, which suggests that children construct knowledge through their experiences and interactions with the environment (Hergenhahn et al., 2010). By engaging in inquiry-based activities, children are given the opportunity to ask questions, test hypotheses, and reflect on their observations—processes that are crucial for the development of both critical thinking and curiosity (Murphy et al., 2015).

Science learning for young children should go beyond merely introducing facts. It should involve active observation, data gathering, prediction, hypothesis testing, and conclusion formulation, as outlined by Putri (2019). These activities help children develop a scientific mindset by encouraging them to ask questions, seek answers, and draw logical conclusions based on evidence. Moreover, science learning at this stage plays a vital role in developing children's cognitive, sensory, and motor skills. Hasbi et al. (2020) highlight that science education can help children understand the world by engaging their senses through activities that involve seeing, touching, smelling, hearing, and tasting.

To address the challenges faced by early childhood science education in Indonesia, this study proposes the adoption of inquiry-based learning (IBL) as an effective teaching strategy. Inquiry-based learning encourages children to explore their surroundings, ask questions, and seek answers through hands-on experiences. This approach aligns with the natural curiosity of young children and fosters critical thinking and problem-solving skills. Hudha et al. (2017) found that inquiry-based learning allows children to actively engage in the learning process, promoting deeper understanding and critical thinking. Moreover, IBL has been shown to increase children's curiosity and engagement, making it an ideal approach for early childhood science education (Eti et al., 2021).

Inquiry-based learning (IBL) offers several advantages for early childhood education. First, it encourages active participation, allowing children to take ownership of their learning experiences. By engaging in hands-on activities, children can explore scientific concepts in a way that is meaningful and relevant to their everyday lives (Ramadani et al., 2021). Second, IBL fosters critical thinking and problem-solving skills by encouraging children to ask questions, make predictions, test hypotheses, and draw conclusions based on evidence. These skills are essential for success in later education and in life (Dewi et al., 2021). Furthermore, inquiry-based learning promotes a deeper understanding of scientific concepts by allowing children to explore the relationships between cause and effect through direct observation and experimentation (Yuliati et al., 2021). This approach helps children develop a more nuanced understanding of the world around them and lays the foundation for future scientific learning (Sangkala & Doorman, 2019). As such, IBL represents a promising solution for addressing the challenges faced by early childhood science education in Indonesia (Hendriarto et al., 2021).

Numerous studies have demonstrated the effectiveness of inquiry-based learning in enhancing critical thinking and curiosity in young children. For instance, a study by Lakin and Wallace (2015) found that children who participated in inquiry-based science activities showed significant improvements in their ability to think critically and creatively compared to those who followed traditional teaching methods. Similarly, research by Stipek, Feiler, Daniels, and Milburn (1995) highlighted that inquiry-based learning not only improves academic outcomes but also increases children's intrinsic motivation to learn, as it nurtures their natural curiosity and desire to explore. Recent findings support these conclusions. For example, McNeill and Krajcik (2018) demonstrated that young children engaged in hands-on scientific inquiry show a stronger understanding of scientific reasoning, enhancing their ability to solve problems. In addition, Haug and Ødegaard (2015) found that inquiry-based activities promote children's critical questioning skills, allowing them to engage more deeply with learning materials. Chen and Looi (2020) also noted that inquiry-based learning can significantly improve metacognitive skills, helping children to reflect on their thought processes and adjust their strategies for problem-solving.

The novelty of this study lies in its focus on early childhood education, where the integration of inquiry-based learning has been less extensively studied compared to older age groups. While much research has been conducted on inquiry-based learning in primary and secondary education, there is still a gap in understanding how this approach specifically benefits young children in their formative years, particularly in terms of developing critical thinking and curiosity. By addressing this gap, this study seeks to contribute to the growing body of literature on early childhood education and provide educators with evidence-based strategies for enhancing children's cognitive development.

The purpose of this study is to explore how inquiry-based science learning can be effectively implemented in early childhood education to promote critical thinking and curiosity. Specifically, this study aims to: (1) examine the impact of inquiry-based learning on children's critical thinking abilities, (2) assess how inquiry-based learning influences children's curiosity and motivation to learn, and (3) provide practical recommendations for educators on how to integrate inquiry-based activities into early childhood curricula to maximize cognitive development. The significance of early childhood development, as defined by the National Association for the Education of Young Children (NAEYC), encompasses the age range of zero to eight years (Aljouf, 2019). This period is particularly influential as children are highly receptive to stimuli provided through educational activities. It is thus imperative that early childhood education (ECE) be designed to optimize their growth by fostering learning experiences that align with their developmental needs. Science learning, in particular, offers a valuable opportunity to stimulate children's cognitive abilities, allowing them to explore, observe, and experiment with their surroundings. Science education for young children is integral to helping them understand natural phenomena and develop critical thinking skills. Through scientific inquiry, children learn to apply knowledge in novel situations, equipping them with tools to face real-life challenges. However, children aged 5-6 still face difficulties in understanding complex cause-and-effect relationships, especially when these connections are not directly observable (Riyani, 2016). Research suggests that young children grasp cause-and-effect more effectively when they can directly observe events, making hands-on and experiential learning essential for their cognitive development.

## 2. METHODS

This study adopted a Research and Development (R&D) approach, specifically utilizing the ADDIE model, to design, implement, and evaluate science learning modules based on the Inquiry Learning method within the framework of the Merdeka Curriculum. The ADDIE model, which stands for Analysis, Design, Development, Implementation, and Evaluation, was chosen for its structured approach to creating and refining educational interventions through systematic stages (Branch, 2009). This method ensures that the science learning modules developed are tailored to meet the specific needs of early childhood students and educators. Each phase in ADDIE allows for detailed planning and iterative testing, making it suitable for continuous improvement and the development of innovative teaching strategies like inquiry-based learning. Moreover, the model's emphasis on evaluation at each stage provides valuable feedback to optimize the modules effectively (Molenda, 2015).

The types of data used in this study include qualitative and quantitative data types. Qualitative data were gathered through observations, interviews, and documentation to capture insights into the teaching and learning process. Quantitative data were collected from pretests and post-tests, allowing for statistical analysis of student performance before and after the implementation of the inquiry-based modules. This combination of data types provided a comprehensive evaluation of the module's effectiveness.

The study employed several data collection instruments, which were carefully designed to measure key variables related to student engagement, critical thinking, curiosity, and understanding of scientific concepts. These instruments included: First, Observation checklists were used to document teacher-student interactions, student engagement during inquiry-based activities, and the overall learning environment. Second, Interviews with teachers were conducted to gain insights into their perceptions of the inquiry-based modules and any challenges they faced during implementation. Third, Questionnaires for students and teachers were used to gather feedback on the learning experience and the perceived impact of the modules on students' curiosity and critical thinking. Fourth, Pretests and post-tests are administered to students to quantitatively assess their understanding of scientific concepts before and after the module implementation. Table 1 summarizes the key indicators and instruments used for data collection.

**Table 1. Key Indicators and Instruments used for Data Collection**

| Indicator | Instrument | Data Collection Method |
|---|---|---|
| Student engagement | Observation checklist | Classroom observations |
| Teacher satisfaction | Interview protocol | Semi-structured interviews |
| Critical thinking skills | Questionnaire | Teacher and student surveys |
| Curiosity | Questionnaire | Student surveys |
| Understanding of science | Pretest, post-test | Test administration |

The data analysis in this study was carried out through a combination of qualitative and quantitative methods to ensure a comprehensive understanding of the effectiveness of the science learning modules.

Qualitative Data Analysis: The qualitative data from observations, interviews, and documentation were analyzed using a thematic analysis approach. The first step was data reduction, where the researcher summarized and categorized the information by identifying key themes and patterns related to student engagement, curiosity, and critical thinking. The next step involved data display, where the reduced data were systematically presented in tables and figures to make the findings easier to interpret. Finally, conclusion drawing and verification were conducted, where the researcher interpreted the data in relation to the research objectives and verified the conclusions through triangulation of multiple data sources to ensure validity.

Quantitative Data Analysis: The quantitative data from the pretests and post-tests were analyzed using descriptive statistics, such as mean scores and percentage distributions, to identify trends and changes in student performance. The comparison between pretest and post-test scores allowed the researchers to measure the impact of the inquiry-based modules on students' understanding of scientific concepts. Inferential statistical analysis, such as paired t-tests, was also employed to determine the significance of the differences between pretest and post-test results, ensuring that the observed changes were not due to chance. The study's data analysis process ensured that the findings were grounded in both qualitative insights and quantitative evidence, providing a robust evaluation of the inquiry-based learning approach's effectiveness.

## 3. RESULT AND DISCUSSION

This study aimed to develop and implement an inquiry-based science learning model for children aged 5-6 years within the Merdeka Curriculum framework, using the ADDIE model as a structured approach. The findings from the study demonstrated the effectiveness of the inquiry-based model in enhancing children's curiosity, critical thinking, and understanding of scientific concepts. In this section, we analyze the results of each stage of the ADDIE model and discuss the findings in light of existing literature to highlight the strengths, challenges, and practical implications of the inquiry-based science learning model for early childhood education.

*Analysis Phase: Identifying the Needs of Teachers and Students*

In the analysis phase, a comprehensive needs analysis was conducted to assess the current state of science education in Raudhatul Athfal (RA) schools and identify the specific requirements of teachers and students within the Merdeka Curriculum framework. The survey results revealed a gap between the existing teaching practices and the goals of the Merdeka Curriculum, with 79.17% of teachers indicating that their institutions had not fully adopted the curriculum (Table 2). This finding is consistent with previous studies that emphasize the challenges educators face when transitioning to new curricula, especially when adopting student-centered approaches like inquiry-based learning (Hamzah et al., 2020). Teachers also expressed a lack of familiarity with inquiry-based teaching methods, with only 25% believing that the approach effectively helped children understand scientific concepts. These findings suggest that teacher training and professional development are critical for successful implementation of inquiry-based learning in early childhood settings. As previous research has shown, professional development programs that focus on building teachers' content knowledge and pedagogical skills can significantly improve the quality of science education (Harris et al., 2017). This is particularly important in the context of the Merdeka Curriculum, which emphasizes student-centered and inquiry-based approaches to learning.

**Table 2. The Questionnaire Survey Result**

| ***Aspect*** | **No** | **Statement** | **Answers Percentages** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **NA** | **SA** | **AE** | **A** | **VA** |
| *Merdeka Curriculum* | 1 | The institution implements learning in accordance with the Merdeka Curriculum | 0% | 79,17% | 20,83% | 0% | 0% |
| | 2 | The Merdeka Curriculum is suitable for learning with children aged 5-6 years | 0% | 0% | 45,83% | 37,50% | 16,67% |
| | 3 | The Merdeka Curriculum supports fun and interactive learning for children aged 5-6 years | 0% | 0% | 37,50% | 37,50% | 25,00% |
| | 4 | The implementation of the Merdeka Curriculum increases the involvement of children aged 5-6 years in learning | 0% | 0% | 83,33% | 0% | 16,67% |
| | 5 | Teachers must master teaching tools in accordance with the Merdeka Curriculum guidelines | 0% | 0% | 12,50% | 50,00% | 37,50% |
| *Science Learning* | 6 | Science learning is important for the cognitive development of children aged 5-6 years | 20,83% | 0% | 25,00% | 16,67% | 37,50% |
| | 7 | Teachers agree that science learning is important for children aged 5-6 years | 20,83% | 37,50% | 0% | 16,67% | 25,00% |
| | 8 | Science learning can motivate children aged 5-6 years to explore and learn more about the world | 0% | 20,83% | 54,17% | 25,00% | 0% |
| *Inquiry Approach* | 9 | Teachers understand the inquiry-based learning approach | 58,33% | 41,67% | 0% | 0% | 0% |
| | 10 | Teachers agree that inquiry-based science learning helps children aged 5-6 years understand science concepts | 0% | 0% | 75,00% | 25,00% | 0% |
| | 11 | Teachers agree that children are more active in learning when using the inquiry approach | 0% | 58,33% | 41,67% | 0% | 0% |
| | 12 | Teachers agree that the inquiry approach effectively fosters children's curiosity in science | 0% | 37,50% | 62,50% | 0% | 0% |
| | 13 | Teachers agree that the inquiry approach encourages children's enthusiasm in exploring activities and discovering new knowledge | 0% | 0% | 100,00% | 0% | 0% |

*Design Phase: Developing the Inquiry-Based Learning Modules*

In the design phase, the research team developed a conceptual framework for the inquiry-based science learning modules. The focus was on creating interactive, hands-on activities that would encourage children to ask questions, make observations, and explore scientific phenomena.

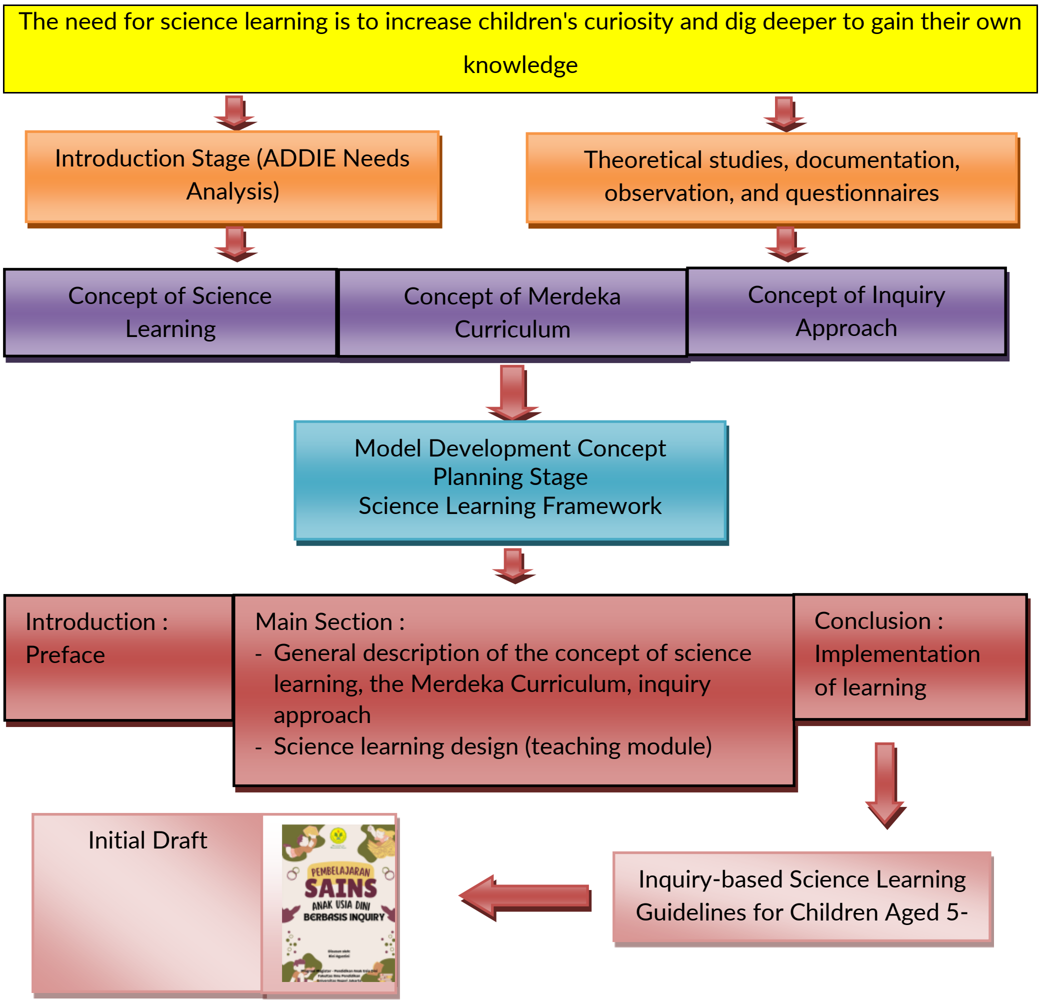


**Figure 2. Framework Design**

The design of the modules was informed by Piaget's constructivist theory, which posits that children construct knowledge through active engagement with their environment (Hergenhahn & Olson, 2010). The design of the modules aligned with existing literature on inquiry-based learning, which emphasizes the importance of allowing children to actively participate in the learning process by investigating and solving problems on their own (Lakin & Wallace, 2015). By incorporating opportunities for exploration and experimentation, the modules were designed to foster curiosity and critical thinking—two essential skills for cognitive development in early childhood. Similar studies have shown that inquiry-based learning can significantly enhance children's scientific reasoning and problem-solving abilities (Dejonckheere et al., 2016).

*Development Phase: Creating and Refining the Learning Materials*

During the development phase, the inquiry-based learning modules, lesson plans, and teaching guides were created based on the design specifications. These materials were structured to promote student engagement and active learning, providing children with opportunities to investigate scientific concepts through hands-on activities. The emphasis on hands-on learning is supported by previous research, which suggests that young children learn best when they can directly manipulate objects and engage in sensory experiences (Yoon & Onchwari, 2014). The development of the modules also involved piloting the materials in small-scale classroom settings to gather initial feedback from teachers and students. The trials revealed that while the modules were effective in promoting engagement and curiosity, some teachers struggled to fully implement the inquiry-based approach due to their unfamiliarity with the method. This finding highlights the need for ongoing teacher support and professional development to ensure that educators can confidently adopt inquiry-based practices (Blanchard et al., 2010).

*Implementation Phase: Piloting the Inquiry-Based Modules*

The implementation phase involved testing the inquiry-based science learning modules in both small and large group settings at RA Al Muttaqiin. The results of the trials showed significant improvements in student outcomes, with pre-test scores improving from an average of 46.29% to 80.57% in small group trials, and from 48.38% to 80.76% in large group trials. These findings are consistent with previous studies that have demonstrated the positive impact of inquiry-based learning on student achievement in science education (Minner, Levy, & Century, 2010). The success of the inquiry-based model in improving students' understanding of scientific concepts can be attributed to the active participation of children in the learning process (Figure 3).

**Figure 3. Learning Implementation with Childrens**

By engaging in hands-on activities such as experiments and observations, children were able to construct their own knowledge and develop a deeper understanding of the material. This is consistent with constructivist theories of learning, which emphasize the importance of student-centered approaches that allow learners to actively engage with and make sense of new information (Fosnot & Perry, 2013). However, the implementation phase also revealed some challenges. Teachers reported difficulties in managing student-led activities and maintaining classroom order during inquiry-based lessons. These challenges are not unique to this study; previous research has also noted that inquiry-based learning can be demanding for teachers, particularly in terms of classroom management and balancing student autonomy with structured guidance (Smyrnaiou, Kynigos, & Roussou, 2016). This suggests that teachers may need additional support in developing strategies for managing inquiry-based classrooms effectively.

*Evaluation Phase: Assessing the Effectiveness of the Inquiry-Based Model*

The evaluation phase involved both formative and summative evaluations to assess the overall effectiveness of the inquiry-based science learning model. The formative evaluations, conducted throughout the development and implementation phases, provided valuable feedback for improving the modules, while the summative evaluations focused on measuring student learning outcomes and teacher satisfaction. The results of the evaluation indicated that the inquiry-based model was highly effective in enhancing children's understanding of science concepts, as evidenced by the significant improvements in post-test scores (Table 3).

**Table 3. Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| 1st Observation Results | 10 | 37 | 57 | 59,17 | 6,142 |
| 2nd Observation Results | 10 | 49 | 58 | 89,41 | 4,102 |
| Valid N (listwise) | 10 | | | | |

The model also succeeded in increasing student engagement and curiosity, as reported by both teachers and students. These findings are consistent with previous studies that have demonstrated the benefits of inquiry-based learning in fostering critical thinking and motivation in young learners (Zion & Mendelovici, 2012). However, the evaluation also identified areas for improvement. While the model improved classroom management to some extent, it did not yield statistically significant results in this area. Teachers may require additional training in classroom management strategies specifically tailored to inquiry-based learning environments. As noted by McNeill et al. (2016), effective classroom management is critical for ensuring that all students can actively participate in inquiry-based activities and benefit from the learning experience.

Upon completing the ADDIE model phases, the science learning modules demonstrated several positive outcomes in terms of student engagement, curiosity, and preliminary classroom management improvements. During the Analysis phase, needs assessments with educators and observational studies of students provided crucial insights into the specific requirements of early childhood learners. This stage ensured the module content was relevant and tailored to student interests, which is foundational to increasing motivation and engagement (Branch, 2009).

In the Design and Development phases, the modules were created to align with the principles of inquiry-based learning, emphasizing interactive activities and hands-on experiences. Research shows that inquiry-based approaches enhance critical thinking and intrinsic motivation by allowing students to engage directly with the learning material (Zion & Mendelovici, 2012). This alignment was validated in subsequent Implementation, where both teachers and students reported significant engagement, with students showing heightened curiosity and active participation in learning tasks. These findings align with McNeill and Krajcik's (2018) work, which suggests that inquiry-based learning is highly effective in nurturing young students' motivation and critical thinking skills through active involvement.

Evaluation outcomes highlighted both the strengths of the module and areas needing improvement. While the module effectively fostered engagement and curiosity, as shown by students' enthusiasm and eagerness to explore new topics, the area of classroom management presented a challenge. Though classroom dynamics improved, statistically significant results were not observed, suggesting a need for refinement in teacher training. McNeill et al. (2016) underscore the importance of specialized classroom management strategies to support the flexibility required in inquiry-based learning settings. Additional professional development for teachers, focusing on adapting classroom management techniques to inquiry-based learning, could further enhance the effectiveness of these modules. In summary, the ADDIE model facilitated the development of a well-structured, engaging module that resonated with both educators and students. By following each ADDIE phase rigorously, this study contributed a tailored learning product that successfully enhanced student engagement and curiosity. Nevertheless, future iterations will focus on incorporating more robust classroom management strategies, as noted in the literature, to fully support inquiry-based learning environments (Branch, 2009; Molenda, 2015).

## 4. CONCLUSION

The development of science learning based on the Inquiry approach in implementing the Merdeka Curriculum for children aged 5-6 years has proven effective in enhancing understanding, curiosity, and critical thinking. The pre-test and post-test results showed significant improvements, indicating that this method promotes active learning and exploration. Teachers reported improved engagement, though challenges remain in mastering the inquiry approach. The findings support that Inquiry-based science learning aligns with the Merdeka Curriculum’s goals, enhancing cognitive development while fostering a more interactive and meaningful learning environment for young children. Further teacher training is recommended to maximize effectiveness.

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