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ARTIFICIAL INTELLIGENCE IN SCIENCE LEARNING TO FOSTER EARLY CHILDHOOD CURIOSITY AT SAVE THE KIDS KINDERGARTEN

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ABSTRACT

Young children are naturally curious, yet science learning in kindergartens often relies on worksheets and teacher explanation, leaving limited room for children to ask questions and investigate, while mobile phone and internet use among young children in Indonesia keeps rising and guidance on using artificial intelligence in early childhood classrooms remains scarce. This conceptual article aims to formulate a teacher-mediated framework for using artificial intelligence to foster curiosity in early childhood science learning, with Save The Kids Kindergarten in Banda Aceh as the context of application. The method is a literature-based review of recent international and national articles, official statistics, national regulations, and international guidance. The results show that artificial intelligence is most useful as a question prompter, an exploration companion, and a documentation aid for teachers, not as a substitute for children's direct experience with real objects and events. The proposed framework has four stages, namely prompting, investigating, reflecting, and documenting, supported by principles of data protection and screen-time limits. In conclusion, artificial intelligence can foster curiosity only when it remains teacher-controlled and subordinate to real experience; because evidence on its effect on kindergarten children's curiosity remains limited, the framework should be tested through classroom research before wider adoption.

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INTRODUCTION

Early childhood is often called the golden age because the foundations of thinking, language, social-emotional skills, and attitudes toward learning begin to form during this period. One of the most striking features of this stage is curiosity. Children observe, touch, take apart, and ask questions about almost everything they encounter. Jirout (2020) defines curiosity as the drive to seek information in order to close knowledge gaps that arise from uncertainty or ambiguity. She shows that this drive is closely tied to how children reason scientifically, that is, by observing, asking questions, making conjectures, and testing them.

In Indonesia's early childhood curriculum, science learning sits within the element of foundations of literacy, mathematics, science, technology, engineering, and the arts, one of the three elements of the foundation-phase learning outcomes (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi [Ministry of Education, Culture, Research, and Technology], 2025). At this stage science is not meant to be memorized but experienced directly, so that it prompts questions, conjectures, and simple explanations. Through classroom action research with children aged five to six at PAUD Nurul Iman in Mataram, Sativa and Buahana (2024) reported that children's cognitive ability rose from 40.35 percent before the intervention to 70.42 percent in the first cycle and 90.37 percent in the second cycle after color-mixing experiments. The authors also linked the increase in children's enthusiasm and curiosity to the novelty of the experiments. That study had no comparison group and measured cognitive ability rather than curiosity directly, but it shows that simple experiments can be carried out in early childhood classrooms in Indonesia.

At the same time, digital technology has entered children's lives. Badan Pusat Statistik [Statistics Indonesia] (2024) recorded that 39.71 percent of young children in Indonesia had used a mobile phone and 35.57 percent had accessed the internet, with the highest proportions among children aged five to six. In 2025, the proportion of young children using a mobile phone rose to 42.25 percent (Badan Pusat Statistik, 2025). Children arrive in class with varied digital experiences, and kindergartens are well placed to steer children's encounters with technology toward more meaningful experiences.

Artificial intelligence, including systems based on large language models, is now being studied for early childhood. Su and Yang (2022) reviewed 17 studies from various countries published between 1995 and 2021 to map how artificial intelligence is used to support children's learning and development. A more recent systematic review of generative artificial intelligence in early childhood education is organized around the perspectives of children, families, and teachers (Zhang et al., 2026). In Indonesia, literature reviews highlight the potential of personalized learning, teacher innovation, and real-time feedback (Fauziddin & Ningrum, 2024). Nevertheless, based on the literature search conducted for this article, studies that specifically connect artificial intelligence with fostering curiosity in early childhood science learning remain very limited, and no study from the Acehnese context was found.

This gap matters because using artificial intelligence with young children is not risk-free. The World Health Organization (2019) recommends strict limits on screen time for young children. UNESCO (2023) warns that generative artificial intelligence platforms

require age regulation and data protection. Indonesia has also enacted Government Regulation Number 17 of 2025, which places child-protection obligations on electronic system operators (Pemerintah Republik Indonesia [Government of Indonesia], 2025). The right question, therefore, is not whether artificial intelligence may enter early childhood classrooms, but in what role, within what limits, and under whose guidance the technology is used so that it genuinely fosters children's curiosity.

This article aims (1) to explain the relationship between curiosity and early childhood science learning, (2) to map recent research findings on the use of artificial intelligence in early childhood education, and (3) to formulate a teacher-mediated framework for using artificial intelligence to foster children's curiosity, with Save The Kids Kindergarten in Banda Aceh as the context of application.

RESEARCH METHODS

1. Research Design

This is a conceptual article based on a literature review. It reports no field data from the kindergarten named; Save The Kids Kindergarten in Banda Aceh serves only as the context in which the proposed framework would be applied.

2. Data Sources and Selection

The material was gathered by searching international and national journals, official statistical publications, and regulations and policy guidance, with priority given to publications from the last ten years. Sources were selected for their relevance to three topics: curiosity, early childhood science learning, and artificial intelligence in early childhood education.

3. Data Analysis

The selected sources were synthesized narratively under the three topics above. The synthesis was then used to formulate the teacher-mediated framework presented in the results.

4. Limitations

The limitations should be stated openly. The article contains no field data from the kindergarten named, so the proposed framework is a conceptual proposal that needs to be tested. Most of the studies cited come from outside Aceh. One study on question prompts involved children aged nine to ten, so its findings must be generalized to kindergarten children with caution.

RESULTS AND DISCUSSION

1. Curiosity and Early Childhood Science Learning

a. Curiosity as a Gateway to Scientific Thinking

Scientific thinking in young children begins with deliberate information seeking, which includes asking questions, making conjectures, observing, and recognizing patterns (Jirout, 2020). Curiosity drives this process. Jirout (2020) describes three mechanisms linking curiosity to science learning. First, curiosity motivates information-seeking behavior. Second, curiosity prompts children to gather relevant information through exploration and questions. Third, the effort to close knowledge gaps leads children to connect new information with prior knowledge, which deepens understanding.

The pedagogical implication is that curiosity cannot simply be left to grow on its own. Surprising or ambiguous situations create uncertainty that triggers questions, and conversations between adults and children help turn that uncertainty into explanations (Jirout, 2020). An example is an object that sinks even though it was expected to float. Jirout (2020) also cites longitudinal findings that parents' early support for curiosity is related to children's intrinsic motivation for science years later. The roles of teachers and parents, both as providers of experiences that prompt questions and as listeners who respond to children's questions, are therefore key factors.

b. Science Learning in the Early Childhood Curriculum

The foundation-phase learning outcomes consist of three elements developed in an integrated way: religious values and character, identity, and the foundations of literacy, mathematics, science, technology, engineering, and the arts (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2025). This formulation places science as part of building a positive attitude toward learning and readiness for primary education, not as a stand-alone subject. In kindergarten, science appears through learning by playing, for example observing plants, mixing colors, or testing objects that float and sink.

Under the play-based approach, the quality of science learning depends on three things: children's opportunities to hold and manipulate real objects, the quality of the questions teachers ask, and room for children to state their conjectures before being given answers. Practical challenges that can be anticipated in class include limited teacher preparation time, a limited stock of activity ideas, and a volume of children's questions that is hard to answer adequately in full. This is where artificial intelligence can serve as a teacher's aid, provided it does not displace children's direct experience.

2. Artificial Intelligence in Early Childhood Education

a. Technology Use by Young Children in Indonesia

Table 1 summarizes the proportion of young children who use mobile phones and access the internet according to Statistics Indonesia. Two patterns stand out. First, the proportion rises sharply with age: in 2024, more than half of children aged five to six had used a mobile phone and accessed the internet, far above the one-to-four age group. Second, overall these proportions rose from 2022 to 2024, for both mobile phones and the internet.

Table 1. Mobile Phone Use and Internet Access among Young Children in Indonesia

Age group (data year)	Using a mobile phone (%)	Accessing the internet (%)
Under 1 year (2024)	5.88	4.33
1–4 years (2024)	37.02	33.80
5–6 years (2024)	58.25	51.19
0–6 years (2024)	39.71	35.57
0–6 years (2022)	33.44	24.96

Source: Badan Pusat Statistik (2022, 2024). Breakdown by age group is shown for 2024 only.

These data are national and do not describe conditions in every region, let alone a single school. This article therefore draws no conclusions about children's digital habits in Banda Aceh. The data only show that children in the kindergarten age group, five to six years, are the group most exposed to devices and the internet, so any discussion of the role of technology in class cannot avoid it.

b. International Research Findings

Two scoping reviews from the same research group give an initial picture. Su and Yang (2022) reviewed 17 studies from 1995–2021 on artificial intelligence in early childhood education. Su et al. (2023) then reviewed 16 empirical papers from 2016–2022 on artificial intelligence literacy in early childhood and identified three main challenges: limited teacher knowledge, skills, and confidence; inadequate curriculum design; and the lack of teaching guidelines. Su and Yang (2023) reported an intervention study in Hong Kong that designed age-appropriate artificial intelligence literacy activities for preschool children.

Another study examined artificial intelligence-interfaced robotic toys in early childhood settings and argued that such devices can support children's inquiry literacy, that is, the ability to investigate and ask questions (Kewalramani et al., 2021). This argument is relevant because inquiry and questioning are tangible expressions of curiosity.

The evidence closest to the topic of curiosity comes from Abdelghani et al. (2023). They tested a conversational agent that uses the GPT-3 language model to generate prompts that elicit children's questions. In a field study of 75 children aged nine to ten, closed prompts generated by the model produced question-asking performance equal to that of human-written prompts, while open prompts that allow many possible questions produced better results. Two lessons can be drawn. First, artificial intelligence can help teachers prepare large numbers of question prompts without excessive workload. Second, open-ended prompts suit the fostering of curiosity better than prompts that steer children toward predetermined questions. Because the participants in that study were not preschoolers, both lessons must be tested with kindergarten-age children.

The systematic review by Zhang et al. (2026) followed the PRISMA 2020 guidelines and organized its findings on generative artificial intelligence by stakeholder: children, families, and teachers. In their introduction, the authors summarize that earlier studies reported gains in language development, creative expression, and children's engagement. The field remains new, and its application to early childhood education is still underexplored.

c. Research Findings in Indonesia

National literature generally takes the form of literature reviews and qualitative studies. Fauziddin and Ningrum (2024) concluded from a literature review that integrating artificial intelligence into early childhood education holds promise for personalized learning, teacher innovation, and real-time feedback. Noviyanti et al. (2023) discussed artificial intelligence-based learning for young children. Aghniya and Tasu'ah (2025) reviewed 20 articles following PRISMA guidelines. Their study was motivated by teachers' low digital literacy and technical skills in developing artificial intelligence-based media suited to children's characteristics, and they recommended an artificial intelligence-friendly curriculum and continuous training. Rizka et al. (2026), using a qualitative case study, identified challenges in integrating digital and artificial intelligence media in early childhood institutions, including limited teacher digital competence and technological infrastructure.

Two consistent patterns appear in the international and national literature. First, teacher readiness repeatedly emerges as a main challenge, alongside the availability of devices. Second, most of the studies reviewed in this article are literature syntheses or small-scale studies, so evidence on the effect of artificial intelligence on young children's curiosity remains very limited.

d. Synthesis: Appropriate Roles and Roles to Avoid

From the findings above, a distinction can be drawn between roles for artificial intelligence that are consistent with fostering curiosity and roles that risk displacing it. Consistent roles are those that help teachers enrich children's experience: preparing open question prompts (Abdelghani et al., 2023), preparing activity variations, helping teachers answer children's questions accurately after checking, and tidying developmental documentation. Risky roles are those that replace direct experience, for example when children receive an instant answer to every question before they have had a chance to conjecture and try things themselves. Instant answers close the knowledge gap too quickly, whereas according to Jirout (2020) that gap is precisely what drives information seeking. This last statement is the author's reasoning based on curiosity theory, not an empirical finding, and therefore needs to be tested in field research.

3. A Teacher-Mediated Framework for Using Artificial Intelligence

a. Design Principles

Based on the review above, the authors propose four principles. First, real experience comes before technology. Children first hold, observe, and try real objects, because the uncertainty that triggers curiosity arises from direct encounters with phenomena (Jirout, 2020). Second, artificial intelligence is controlled by the teacher. Children do not interact alone with generative artificial intelligence platforms, in line with UNESCO's (2023) caution about independent use by children. Third, prompts are open. Questions produced by the tool must allow many answers and must not lead children (Abdelghani et al., 2023). Fourth, children's data are protected. No child's name, face, or voice is entered into an online platform, in line with the direction of child protection in Government Regulation Number 17 of 2025.

b. A Four-Stage Cycle: Prompting, Investigating, Reflecting, Documenting

These principles are operationalized in a four-stage cycle mapped onto the three mechanisms of curiosity described by Jirout (2020). Prompting relates to the emergence of uncertainty that gives rise to questions. Investigating relates to gathering information. Reflecting relates to connecting new information with children's experience. The fourth stage, documenting, was added by the authors so that teachers have a basis for planning follow-up. Table 2 details the activities, the role of artificial intelligence, and the observable indicators of curiosity at each stage. This cycle is the authors' conceptual proposal, not a model that has been tested.

Table 2. A Teacher-Mediated Cycle for Using Artificial Intelligence

Stage	Teacher and child activities	Role of artificial intelligence (teacher-controlled)	Observed indicators of curiosity
1. Prompting	The teacher presents a surprising real phenomenon, for example objects that float and sink. Children state their conjectures.	Helps the teacher prepare open prompt questions and variations of objects or phenomena before the activity.	Children ask spontaneous questions, state conjectures, and observe for longer.
2. Investigating	Children try, compare, and observe results with real objects.	Helps answer children's questions that the experiment does not resolve. The teacher screens answers before sharing them.	Children repeat experiments, try new variations, and ask follow-up questions.
3. Reflecting	The teacher invites children to describe their findings and connect them to everyday experience.	Helps the teacher draft reflection questions and short stories suited to the developmental stage.	Children explain in their own words and connect findings to their experience.
4. Documenting	The teacher records children's questions, conjectures, and development.	Tidies the teacher's notes into a summary and suggests follow-up themes, without children's identifying data.	The list of children's questions grows over time, and follow-up themes arise from children's questions.

Source: the authors' formulation, drawing on Jirout (2020) and Abdelghani et al. (2023).

c. An Illustration: The Theme of Water

As an illustration, not a research result, imagine the theme "Water" in a group of children aged five to six. Before the activity, the teacher asks artificial intelligence to draft ten open questions about floating and sinking objects, then chooses the three that best fit children's language. In the prompting stage, the teacher shows a marble and a leaf in a basin of water and asks children to guess what will happen. In the investigating stage, children try various objects from around the classroom. When a child asks why a large ship does not sink, the teacher checks the explanation suggested by the tool, simplifies it, and delivers it herself with a demonstration. In the reflecting stage, children talk about their findings. In the documenting stage, the teacher records the children's questions and uses the tool to tidy the notes into a summary without children's names.

d. Prerequisites

This framework works only if three prerequisites are met. The first is teacher competence. Su et al. (2023), Aghniya and Tasu'ah (2025), and Rizka et al. (2026) all

identify teachers' knowledge, skills, or digital competence as a main challenge. Short, repeated training, peer mentoring, and ready-to-use activity kits are therefore more realistic than one-off training. Teachers' digital literacy in early childhood education is already a research concern in Indonesia (Hardiyanti & Alwi, 2022; Novitasari & Fauziddin, 2022) and needs to be extended to artificial intelligence literacy.

The second prerequisite is parental involvement. The role of parents in children's use of digital technology has been discussed in national literature (Asmawati, 2021), and Mauluddia and Yulindrasari (2024) discuss the role of digital literacy in supporting child development. Schools can explain to parents how and why artificial intelligence is used in class, while stressing that children's own screen activity is very limited. The third prerequisite is devices and language. A single teacher-owned device or laptop used under the teacher's control is sufficient, so costs are relatively low. Because children in Aceh may grow up with Acehnese, Indonesian, or both, teachers need to check the accuracy of language and cultural content in the tool's output before using it.

4. Risks, Ethics, and Child Protection

The first risk is screen time. The World Health Organization (2019) does not recommend sedentary screen time for children under two and advises that children aged three to four have no more than one hour per day, with less being better. These guidelines do not address artificial intelligence specifically but are relevant as a precautionary limit. In the proposed framework, artificial intelligence is used mainly by the teacher, while children's exposure to screens consists only of brief moments shared together, not independent screen activity.

The second risk concerns age and accuracy. UNESCO (2023) cites 13 as the commonly applied age threshold for independent conversations with generative artificial intelligence platforms and urges countries to deliberate the appropriate age limit, while some argue for 16. Kindergarten children are far below this threshold. Language model output can also be wrong or biased, so every answer to be given to children must be checked by the teacher first.

The third risk concerns data protection and regulation. Government Regulation Number 17 of 2025, which took full effect on March 28, 2026, sets obligations for electronic system operators to protect children, including prohibitions on profiling children, collecting children's location data improperly, and applying behavioral nudge techniques in service features (Pemerintah Republik Indonesia, 2025). This regulation burdens platform providers, not schools. Even so, schools still need to choose tools consistent with these principles and avoid entering children's identities into online services.

5. Implications for Save The Kids Kindergarten, Banda Aceh

For Save The Kids Kindergarten in Banda Aceh, this framework can serve as the basis for a small classroom-based pilot. Realistic first steps are to map children's device-use habits and teacher readiness through a simple questionnaire, to give teachers short training on creating open question prompts and checking tool output, to carry out one science theme using the four-stage cycle over several weeks, and then to reflect on the results together with parents.

For the pilot to produce accountable evidence, the curiosity indicators in Table 2 can be recorded through teacher observation sheets, the number and types of children's questions, and anecdotal notes, then compared before and after the cycle. A design-based research approach, which allows the framework to be refined repeatedly together with teachers, suits this stage. The results of the pilot could later be written up as a research article.

CONCLUSIONS AND SUGGESTIONS

1. Conclusion

Curiosity is young children's natural capital for learning science, but that capital must be nurtured through experiences that prompt questions and conversations that respond to children's questions. The literature review shows that artificial intelligence has the potential to help teachers, especially in preparing open question prompts, answering follow-up questions, and tidying documentation. However, evidence of its effect on kindergarten children's curiosity remains limited. Teacher readiness, parental guidance, screen-time limits, and protection of children's data determine whether that potential is realized.

The proposed four-stage framework, namely prompting, investigating, reflecting, and documenting, positions artificial intelligence as a teacher-controlled aid and places real objects and events at the center of children's experience. The framework has not been tested, so its status is that of a working hypothesis.

2. Suggestions

Recommendations for teachers are to start with one science theme and one function of artificial intelligence, such as drafting prompt questions, and always to check tool output before using it. Recommendations for schools are to draft simple internal guidelines on children's data and screen time and to share them with parents. Recommendations for researchers are to test this framework through field research with kindergarten children using clear measures of curiosity, including in the Acehnese context, which remains rarely studied.

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