Application of Science, Technology, Engineering, Art, and Mathematics to Improve Critical Thinking Skills of Children Aged 4-5 Years

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Abstract:

The low ability of children's critical thinking is caused by various things, one of which is the limitations of educators in providing space for students to stimulate necessary thinking skills in the learning process. The learning approach, methods, and media have yet to help children fully build critical thinking skills. Overcoming these problems is one way that can support the achievement of children's necessary thinking skills with the STEAM (Science, Technology, Engineering, Art, and Mathematics) learning model. This research method uses classroom action research methods to improve and increase the quality of learning regarding critical thinking skills. Based on the study results, there was an increase in all indicators of critical thinking in the development of student learning outcomes after being given action. The ability to think critically in children is evidenced by the average achievement category of Very Developed Children (BSB), with a percentage of in cycle one of 48.75% and in cycle two reaching 80.25%. The application of STEAM learning can improve critical thinking skills.

Keywords: Critical thinking skills; STEAM; Early childhood education

INTRODUCTION

Early childhood is a child ranging from birth to 6 years of age; this is stated in the Law of the Republic of Indonesia Number 20 of 2003 concerning the National Education System 2003. Article 1, paragraph 14 further explains the definition of Early Childhood Education, which is guidance shown to children from birth to six years of age, which is done through providing educational stimuli to help the physical and spiritual growth and development of children to have readiness for further education. The National Association of the Educational of Young Children (NAEYC) explains that children aged birth to 8 years are eligible for educational services (Bredekamp & Copple, 1997). This opinion is corroborated by the results of research, which stated that children's lives during the first eight years need to be maximized for their development (Khaironi, 2018). Montessori mentioned that early childhood is a sensitive period for children and that their development needs to be stimulated optimally; thus, they do not experience developmental delays (Hurlock, 1978). From the opinions of some experts above, it can be concluded that early childhood is a child aged 0 to 8 years where the child experiences growth and development. In comparison, Early Childhood Education (ECE) is aged 0 to 6. Through early childhood education, children are

given stimuli to help with their physical and spiritual growth and development to be ready for further education. In the Islamic perspective quoted from the translation of the verse in surah An-nahl verse 78, Allah SWT says, "And Allah took you out of your mother's belly knowing nothing, and He gave you hearing, sight, and conscience so that you would be grateful." The above verse explains that children are born in a weak state and do not have any knowledge. As is the case with early childhood who do not understand anything about the surrounding world. Allah SWT gives humans three abilities, namely hearing, sight, and feelings, through conscience so that children gain extensive knowledge. Ornstein (Sawyer, 2003) conveyed that providing appropriate stimulation of children's brain development will positively impact children's readiness to enter primary school. Accordingly, it can be concluded that the need to stimulate children from an early age to gain knowledge includes understanding and relevant basic knowledge, and developing the ability to master practical skills is essential. According to Prameswari & and Lestaningrum (2020), the stimulation provided needs to be adjusted to the child's condition and period to achieve maximum development of children's abilities. One way to prepare children for the future amid the demands of the times is to teach them problem-solving skills that involve critical thinking, creativity, collaboration, and communication, known as the 4Cs (Kembara et al., 2019). These are the 21st-century education skills that are indispensable for learners. The primary basis for the development of 4C is based on Bloom's theory, which emphasizes the importance of thinking skills in the learning process where children must be able to achieve three domains of intellectual abilities, including cognitive, affective, and psychomotor to prepare children to face the challenges of life in a complex manner and become resilient and successful individuals (Heldanita et al., 2023)(Nurjanah & Wahyuseptiana, 2018).

According to Prameswari & Lestaningrum (2020), the stimulation provided needs to be adjusted to the child's condition and period to achieve maximum development of children's abilities. One way to prepare children for the future amid the demands of the times is to teach them problem-solving skills that involve critical thinking, creativity, collaboration, and communication, known as the 4Cs (Kembara et al., 2019). These are the 21st-century education skills that are indispensable for learners. The primary basis for the development of 4C is based on Bloom's theory, which emphasizes the importance of thinking skills in the learning process where children must be able to achieve three domains of intellectual abilities, including cognitive, affective, and psychomotor, to prepare children to face the challenges of life in a complex manner and become resilient and successful individuals (Heldanita et al., 2023)(Nurjanah & Wahyuseptiana, 2018).

Smith (Fauzia, 2022) states that a person's critical thinking skills are "essential core life skills" that everyone must currently own. These skills must be honed by inviting them to explore, solve problems, and express their ideas. Hardika (Hakim, 2020) suggests that critical thinking is critical in human life to make decisions and solve problems. However, it cannot be denied that, in reality, the ability to think critically is still low; this situation is caused by various things, one of which is the limitations of educators in providing space for participants, the lack of teacher creativity, and innovation in stimulating critical thinking skills in the learning process (Priyanti & Warmansyah, 2021). The learning approach, methods, and media used have yet to facilitate children's total development of critical thinking skills. A similar situation occurred at Thoriqul Jannah Islamic Kindergarten, based on observations and interviews with the principal researchers at Thoriqul Jannah Islamic Kindergarten. According to Mrs. Deska, children still need stimulation to develop critical thinking skills. Children cannot independently solve problems and do not dare to express their opinions when exploring learning resources in play activities. Overcoming the difficulties in Thoriqul Jannah Islamic Kindergarten, Sinjai Regency, researchers are

interested in adopting the STEAM learning model to stimulate children's critical thinking skills. Nurfadillah & Rakhman (2020) suggested that one of the learning models that can be used to develop the nature of learning and improve problem-solving is the STEAM-based learning model (Science, Technology, Engineering, Art, and Mathematics). According to Imamah & Muqowim, STEAM learning comprehensively incorporates various subjects, such as science, technology, engineering, art, and mathematics, in the context of problem-solving. From this, STEAM learning has significant benefits because, in addition to helping students to adapt to the times, STEAM also allows learners to pursue the knowledge and skills they will achieve (Prameswari & Lestaningrum, n.d.). In this context, students can hone their critical thinking skills through the science and math components integrated into STEAM learning.

In line with research conducted by Wahyuseptiana (2022) at Aisyiyah Al-Amin Bibis Kindergarten, Surabaya City, where the implementation of the learning process with the STEAM approach shows an influence on critical thinking skills in children aged 5-6 years. Applying the STEAM approach in learning activities certainly provides opportunities for students to think critically and decide on problems that occur in the surrounding environment later. However, this study offers a difference from previous research, namely that researchers want to see how the application of STEAM learning in children with an age range of 4-5 years. In addition, this study also presents more specific indicators that researchers use as a foothold for researchers to see an increase in critical thinking skills in STEAM learning tailored to the achievements of children aged 4-5 years. The purpose of this research is to find out how the application of STEAM learning improves critical thinking skills in children aged 4-5 years.

METHOD

This classroom action research directly describes the STEAM model's application to improve critical thinking skills. The subjects were Group A3 students in kindergarten Islamic Thoriqul Jannah School Year 2022/2023, which amounted to 15 students with an average age of 4-5 years. This classroom action research was conducted in the form of active participation. The researcher was directly involved in all stages of the research, from planning to finishing the research. The researcher continued to monitor, record, and collect data during the research process, then analyzed the data and finally reported the results of his research. This action research consists of planning, action implementation, and observation, then evaluation and reflection. The stages were arranged in two cycles with five meetings per cycle (Widayati, 2008).

Data was collected using observation, work results, checklists, and documentation. The data obtained in this study were analyzed qualitatively and descriptively using the percentage method, which compares the acquisition score of the maximum score of all children involved and then multiplied by 100%. The analysis results are employed as initial data in carrying out the first meeting until the last meeting until reaching the target, which must match the completeness criteria from the school agreement with the researcher, namely 76% to 100% with the assessment category Developing Very Well.

RESULTS AND DISCUSSION

ECE requires learning innovation to stimulate children to think critically and creatively and be fun for children. Simoncini & Lasen (2018) state that the role of STEM/ST-

EAM in ECE lies in the foundation of "habits of mind" by emphasizing the involvement of children to actively explore and investigate the surrounding environment with hands-on activities and conceive early childhood as effective communicators and able to express themselves and express ideas. In Simoncini's opinion above, the application of STEAM certainly supports children's creativity and innovation while playing, aiming to develop critical thinking skills, namely reasoning, predicting, hypothesizing, problem-solving, and critical thinking.

In line with research articles that have been reviewed and are relevant to STEAM learning in improving children's critical thinking, including research from Roshayanti regarding the STEAM approach to improving necessary thinking skills in early childhood, Prameswari & Lestaningrum (2020) STEAM learning using media loose part in improving 4C skills, and research conducted by Zakiyatul Imamah and Muqowim (2020) with the development of creativity and critical thinking in early childhood through STEAM-based learning methods and loose part. These three studies show the effect of STEAM learning on improving children's necessary thinking skills. Children's essential thinking skills observed by researchers this time are focused on activities that apply five areas in STEAM learning. STEAM in this study is an activity carried out by children with the following criteria;

1) Science: Children's ability to be curious and participate in conducting experiments. Such as observing what happens, classifying, predicting what happens to formulate conclusions from the problem. According to Dodge, Colker, Heroman (Safira & Ifadah, 2020), science combines the process skills of how children learn and the content of what children learn. According to Rutherford & Ahlgren (Yafie & Sutama, 2019), science is essential. It is the basis for early childhood education programs because children interact with the natural environment around them every day.

2) Technology is children's ability to use simple technology, namely the tools children use when learning, such as laptops, in observing videos before core activities. Technology in the early childhood world allows children to understand how tools work and is not associated with something sophisticated, such as electric cars or smartphones (Farwati et al., 2021).

3) Engineering is the ability of children to assemble or build a specific shape using various media. Engineering is the knowledge to operate or design a procedure to solve problems (Ramadan et al., 2019).

4) *Art* or Art is the ability of children to explore in producing a work. Art allows students to illustrate STEM concepts in creative and imaginative ways, express ideas about the world through music and dance, communicate with descriptive language, create graphics, and build models (Roshayanti et al., 2022).

5) Math, children's ability to compare, sort, work with patterns, and identify shapes. Sriningsih (Syafdaningsih & Utami, 2021) suggests that mathematics in early childhood is a means that can be used to develop various intellectual potentials and can be used as a means to foster different positive attitudes and behaviors in order to lay the foundations of personality as early as possible such as critical, resilient, independent, scientific and rational attitudes.

According to Natalia (2021), critical thinking involves a more profound process than passively receiving information, where individuals critically question, explore, and interpret information before reaching conclusions or taking action. Halim (2022) says that practicing critical thinking regularly can improve an individual's ability to understand more deeply, see more than one point of view, make better decisions, and produce more effective solutions. In this case, critical thinking provides a strong foundation for rational and informed thinking so that children do not just take information for granted. By thinking critically, children form

and build their own opinions, see with their point of view, and get used to finding out to get a fact. The scope of development according to children's age level in Permendikbud Number 137 of 2014 includes religious moral values, physical motor skills, cognitive skills, language skills, social-emotional skills, and art. Judging from the suitability with the Standard Level of Development Achievement described in Permendikbud No. 137 of 2014, critical thinking is part of the scope of cognition and language. In cognitive development, three achievements must be stimulated: learning from problem-solving, logical thinking, and symbolic thinking. The aspect of language development is that children understand receptive language, which includes the ability to understand stories, and children can express language, which consists of the capability to ask questions, answer questions, communicate verbally, and retell what they want to know.

This study focuses on early childhood cognitive development, namely the scope of critical thinking for children aged 4-5 years in the form of the ability to identify problems with the ability to recognize the concept of size by comparing activities, collect relevant information with the ability to connect cause and effect, compile alternative problem solving with the criteria that children can conduct experiments, and express opinions with the requirements that children express their opinions. Berk (Fauzia, 2022) says that cognitive is related to the process of knowing where a child digests information and stimulation received by the five senses, then processes it and uses the information and knowledge to solve problems or to react and respond to everything the child faces. Neisser (Fauzia, 2022) suggests that the expected results of children's cognitive development are that children can think logically and critically, make reasons according to context, solve problems, and link cause and effect in the issues they are facing.

In this context, activities that hone children's critical thinking skills, according to Fauzia (2022), can be done with a scientific approach as recommended by the government through the 2013 curriculum in the ECE curriculum learning guidelines, which states that a scientific approach is an approach in building children's way of thinking to have the ability to reason obtained through the process of observing, questioning, gathering information, reasoning and communicating. Norris and Erris (Lismaya, n.d.) suggest five stages included in the critical thinking process of children, namely classifying issues, gathering information, starting to reason, gathering information, and making and communicating decisions. Based on the explanation above, the researcher concludes that there are steps in the critical thinking process in early childhood, namely children observing using all senses (sight, hearing, smell, touch, and taste), then children questioning or asking questions, gathering information to find an answer to the questions raised by children at the questioning stage, children reasoning through points of view, and finally communicating decisions as a strengthening of new knowledge and skills that children have gained which is done in various ways, for example; oral language, movements and works.

In this study's application of STEAM learning, the observation stage is then carried out during the learning process, where the researcher directly observes the development of children starting from the opening, core, and closing activities. Followed by several stages of critical thinking, children begin to gather information through questions that children ask. Children begin to associate (reason) by connecting what they know before with new experiences after listening to the video provided, which will be seen in the core activities of how children communicate and utilize the information they collect. From the research results in cycle one, researchers noticed no overall increase in critical thinking skills indicators, so improvements needed to be made in the next cycle. The table below shows the results of observations in cycle I.

Table 1. Recapitulation of the Average Value of Indicators in Improving Children's Critical Thinking Skills in Cycle I

Indicator	Meeting I	Meeting II	Meeting III	Meeting IV	Meeting V	% average
Children can recognize the concept of size by comparing	37%	47%	52%	63%	67%	53%
Children are able to recognize cause and effect	35%	42%	45%	57%	60%	48%
Children are able to solve simple problems they face	38%	42%	53%	60%	63%	51%
Children can express ideas/opinions	33%	37%	42%	45%	58%	43%

The indicator of children's ability to recognize the concept of size by comparing with an average percentage of 53%, the indicator of children's ability to know the cause and effect of the average percentage obtained is 48%, the indicator of children's ability to solve simple problems encountered with an average percentage of 51%, and the indicator of children's ability to express their ideas/opinions with an average percentage of 43%, it appears that there has been no overall improvement. The lowest indicator is in the indicator of children's ability to express ideas/opinions, where children still need more courage to express their ideas/opinions. At the first meeting, in problem-solving activities, from the aspects measured, namely how children can understand the problems they face and can find solutions with their own opinions and thoughts, only a few are active.

Teachers' efforts to improve critical thinking include introducing the size concept by comparing activities. (K. M. Simoncini et al., 2018), suggests several aspects developed based on necessary thinking skills from Brookfield (1987) when wanting to build children's critical thinking. One is with Analysis (analysis) by involving, recognizing, and making categories. Usually, a child can categorize and compare. By providing opportunities for children to do direct comparing activities through measurement concepts, in terms of comparing two objects, for example, from the size of length-short, height-low, weight-light, thick-thin, etc., the researcher provides activities in this first meeting, namely pipe installation with children choosing and comparing the suitable pipe to use. For this reason, the researcher provided an activity at this first meeting, namely pipe installation, with children choosing and reaching the suitable pipe to use. Children can look at similarities and differences with their senses, detect minor points of difference, see mistakes, and find differences between objects. This learning activity will help teachers understand children's different thinking skills.

The activities carried out in the second action are conducting experimental activities covering all STEAM learning areas. One of the benefits of practical activities is to develop children's curiosity, critical thinking, and learning abilities. The activity carried out in experimental activities before the child starts doing it himself is the child observing. According to Fernández-Santín & Feliu-Torruella (2020), some ways can be done to improve critical thinking, namely developing the ability to follow, in this case by observing

children problem-solving from events or things that are observed, thus making it easier for a child to explore critical thinking skills. In the experimental activities where water has weight, children measure themselves and find out why the glass that has been filled with water falls while the glass that is not filled with water moves up by trying several times. Finally, the child can conclude that because water has weight, the glass moves down.

Furthermore, the children tried to make the tea independently in the experiment of water dissolving certain substances by dissolving tea. They made the same color as the tea made by the teacher, namely with a long soaking time while stirring. It is concluded that the second action through experimental activities can improve children's critical thinking skills. Children are more willing to express their opinions, find solutions that must be done, and are not afraid to ask questions.

After the second action or at the second meeting, children's ability to recognize the concept of size by comparing with a percentage of 47%, it can be seen that the percentage value has increased; there are three children with developing criteria as expected, then the indicator of children's ability to know cause and effect with a percentage value of 42%, the ability of children to solve simple problems they face increases with an average percentage of 42% with the number of children who are still not developing remaining five from the first meeting as many as nine children out of 15 children. For indicators of children's ability to express ideas/opinions with a percentage value of 37%, but in this indicator, the number of children who have not developed is eight children.

In addition, this indicator increased again at the fifth meeting in this first cycle with the number of children with the criteria developing as expected the most, namely ten children with a percentage value of the indicator obtained of 60%. The activities given at this fifth meeting were road-making projects using sand. Children compared how many sand trucks are used to make roads. In addition, children also compare which is faster when filling sand, whether using a spoon or a bowl. In this comparison activity, children can develop critical thinking skills by identifying problems and how children can organize themselves in deciding something right. From STEAM learning, knowing the concept of size with this comparing activity is part of the field of mathematics, which can train a systematic and organized thinking process in solving a problem. Amaluddin n.d (2008) suggests that mathematics in early childhood is a means that can be used to develop various intellectual potentials and can be used as a means to foster various positive attitudes and behaviors in order to lay the foundations of personality as early as possible such as critical, resilient, independent, scientific and rational attitudes.

In developing the ability to recognize cause and effect in early childhood, including providing opportunities for children to gain direct experience in various integrated and meaningful learning activities, starting activities by creating a conflict in the child's mind, providing opportunities for children to do various activities that can develop their cognitive abilities, conducting question and answer activities that can encourage children to think and express their thoughts. Learning to recognize cause and effect in children after early childhood can be done by introducing the process of occurrence of something that is around the child, such as the occurrence of events in everyday life such as rain, rainbows, natural disasters (volcanic eruptions, landslides, earthquakes, floods, etc.) as researchers have done in cycle I, one of which is on the theme of the earth sub-theme of rain by introducing children to the process of rain. In the activity of dramatizing the process of rain by integrating five fields in STEAM, children act out directly how rain can occur, and as evidenced by the results of research on the third action of cycle I, the increase in children's ability to know cause-and-effect to 45% with the number of children starting to develop rose to 12 children.

According to Hamalik (2010), the causality or cause-and-effect thinking pattern is based on a belief that all causes will lead to inevitable consequences, and vice versa; all phenomena that occur are caused by the cause. Therefore, introducing the concept of cause-and-effect to children is considered necessary. Moreover, introducing the concept of cause-and-effect can improve children's reasoning ability when thinking about something more profound. In problem-solving activities, the aspects measured in this indicator are how children can understand their problems and find solutions with their opinions and thoughts; at this first meeting, only a few were active. Piaget suggested that children should be able to conduct their experiments and research. Teachers only guide children by providing suitable materials and, most importantly, so that they understand something, build their understanding, and find solutions. Noting Piaget's explanation for this reason, the teacher began to encourage children to ask more questions in the water filtration experiment activity. The teacher asked an open question, "Why can this murky water turn clear?" with this question, the child then found out for himself by seeing the process of filtering water using cotton, tissue, gravel, stones, sand, and charcoal and then letting the child explore through his play activities so that the effort can find out the problem and be able to find out the solution to the problem himself. The lowest percentage in cycle one in critical thinking skills is in the indicator of children's ability to express their ideas/opinions, with a percentage value of 43% at the first meeting with ten children who have not developed, where children have not dared to familiarize themselves with expressing ideas in exploring their surroundings. However, the indicator of children's ability to express ideas increased at the fourth and fifth meetings in this first cycle, with a percentage value at the fourth meeting of 45%, with the number of underdeveloped children remaining three children and starting to develop, reaching 12 children. In comparison, the fifth meeting of children began to develop as expected by as many as six people, with a percentage of 58%.

The activities given at this meeting are making zoos and flower gardens in the micro role center. In this activity, children explore pouring their ideas into making a zoo using synthetic sand as a substitute for soil. The child makes a shelter that the child says is a cave a shelter for animals. From this activity, children recognize the benefits of land, as they can get used to expressing ideas. One of the characteristics of critical thinking skills is the ability to express opinions where they can provide logical reasons, show facts that support their opinions, and provide good ideas or ideas. Critical thinking is vital in assessing the merits of new ideas, selecting the best ideas, and modifying them if necessary, so it helps carry out creative activities. There has not been an increase in the achievement of improving children's critical thinking skills in cycle one, so action is taken in the second cycle. Research in the second implementation cycle is the same as the implementation in the first cycle, except that the activities in each center are different at each meeting. The observation results in this second cycle are presented in the following table:

Table 2. Recapitulation of the Average Value of Indicators in Improving Children's Critical Thinking Skills in Cycle II

Indicator	Meeting I	Meeting II	Meeting III	Meeting IV	Meeting V	% average
Children can recognize the concept of size by comparing	70%	77%	78%	90%	93%	81,6%

Indicator	Meeting I	Meeting II	Meeting III	Meeting IV	Meeting V	% average
Children are able to recognize cause and effect	70%	75%	80%	80%	90%	79%
Children are able to solve simple problems they face	73%	78%	78%	83%	95%	81,4%
Children can express ideas/opinions	68%	75%	78%	80%	88%	78%

Research in the second cycle at Thoriqul Jannah Islamic Kindergarten in group A3 aged 4-5 years showed an increase in children's critical thinking skills in the indicator of the ability to recognize the concept of size with comparing activities with the average percentage obtained of 81.6%, the ability of children to know cause and effect 79%, as well as the ability of children to solve problems faced 81.4%, and the ability of children to express ideas/opinions with an average percentage of 78%.

At the first meeting of the second cycle in the micro role center, with the optional activities provided, namely assembling satay burning from the materials provided, making/processing satay from playdough, and continued with plating activities according to the number of orders. From this activity, the observation result obtained on recognizing the concept of size by comparing activities is 70%. Furthermore, the indicator of children's ability to recognize the concept of size by comparing activities at the fourth meeting with the acquisition percentage increased to 90%, with activities carried out by children, namely the lava lamp experiment. The average child independently tries to experiment themselves, observing and comparing if more vinegar solution is given, more bubbles will be seen.

At the indicator of children's ability to know cause-and-effect at the first meeting in this second cycle with a percentage obtained of 70%, although it seems that there is an increase from the first cycle, it still requires action in developing children's critical thinking skills, especially in indicators of children's ability to know cause-and-effect in an event. For this reason, at the next meeting, the researcher invited children to observe the process of earthquakes directly by making mock-ups of earthquake phenomena as a simulation of earthquakes. From this activity, children more quickly know the cause of the land moving, as seen when children more quickly understand and explain what happened. The increase in indicators of children's ability to know cause and effect increased dramatically after being given this activity, which increased to 80%, with four children developing very well. Likewise, the child's ability to solve problems after the action at the third meeting increased with a percentage value of 78%.

Children's ability to express ideas was seen an increase in the second meeting of cycle two, and the researcher invited children to make a bonfire using used plastic bottles wrapped in red yellow and opening colored oil paper according to the color of the fire and LED lights to provide fire effects. Children find out how this campfire can look bright by bringing it to a dark place and then turning off the classroom lights as if the children lit a campfire at night. The percentage of acquisition on this indicator reached 78% and saw an increase again at the fourth meeting, with a percentage of acquisition reaching 80%, where children can express their ideas in experimental lava lamp activities. The results of observations during the implementation of the second cycle showed an increase in each child

critical thinking indicator. The average number of critical thinking indicators in this cycle is 80.25%, with a very well-developed category showing an increase in this second cycle. The research results in children's critical thinking skills are by the school's completeness criteria of 76% - 100% with very well-developed criteria. This increase shows that STEAM learning can improve critical thinking skills in children aged 4-5.

CONCLUSION

Based on the results of classroom action research conducted in cycle one to cycle two at Thoriqul Jannah Islamic Kindergarten, it is known that STEAM learning can improve critical thinking skills in children aged 4-5 years. The increase occurred in all indicators, with the average value of children's critical thinking skills obtained in this study reaching 80.25% by the school's completeness criteria of 76% - 100%, indicating success. Applying STEAM learning certainly greatly supports children's creativity and innovation while playing to develop critical thinking skills in children. For this reason, it is recommended in future research to develop STEAM learning, where through the STEAM learning model, children are trained to play, observe, create, and learn to become critical-thinking individuals.

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