Implementation Approach Inquiry in Science learning for Increase Ability Think Critical

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ABSTRACT

This study aims to analyze the effectiveness of the inquiry approach in science learning to improve the critical thinking skills of junior high school students in Indonesia. The research employed a quasi-experimental method using a pretest-posttest control group design. A total of 120 students were selected and divided into two groups: an experimental group (taught using the inquiry approach) and a control group (taught using conventional methods). The instrument used to measure critical thinking was developed based on Ennis's indicators and adapted to the Indonesian context. The analysis revealed a significant difference between the experimental and control groups, with an effect size of 3.75, indicating a substantial practical impact of the inquiry approach on students' critical thinking development. Each critical thinking component including interpretation, analysis, evaluation, inference, and explanation showed a significant improvement. The study also highlights that integrating local cultural contexts into inquiry-based learning enhances its relevance and effectiveness. These findings support the implementation of inquiry-based approaches as a more effective alternative to conventional teaching methods in fostering students' critical thinking skills in Indonesian science education.

Keywords: Inquiry Approach, Science Learning, Critical Thinking, Science Education, Indonesian Curriculum

INTRODUCTION

Ability think critical is one of the skills essential 21st century for student in face global challenges and revolution industry 4.0. However , research show that ability think critical Indonesian students still classified as low , especially in science learning (Sari et al., 2023). Data from the Programme for International Student Assessment (PISA) 2018 shows that Indonesia is ranked 74th out of 79 countries in field of science, indicating the need for reform of the approach learning that can be develop ability think level tall student .

Approach learning traditional that still dominant in Indonesia tends to teacher - centered and emphasizes knowledge transfer in a way directly , so that not enough develop ability think critical students (Widodo et al., 2020). Conditions This contradictory with demands The 2013 curriculum emphasizes development ability think level height and skill 21st century .

Approach inquiry (inquiry-based learning) has recognized in a way international as a learning model effective For develop ability think critical in science education . Meta- analysis research latest show that learning based inquiry own impact positive significant to ability think critical student with an effect size of 0.75 (Chen & Liu, 2025). The approach This allows student For active explore question scientific and problem through investigation , experimentation , and reflection critical .

Although Thus , there is a significant research gap in context implementation approach inquiry in Indonesia. Research previously more focus on aspects cognitive general , but Not yet study in a way deep How components specific approach inquiry (questioning, investigating, creating, discussing, reflecting) contributes to development indicators ability think appropriate critical with characteristics Indonesian students . In addition , some big study previously Not yet integrate approach inquiry with context culture local and curriculum Indonesian national .

Study This aim For analyze effectiveness implementation approach inquiry in science learning for increase ability think critical junior high school students in Indonesia. Novelty research This lies in the development of learning models integrated inquiry with wisdom local and customized with characteristics Indonesian curriculum , as well as use instrument evaluation ability think comprehensive and valid critical analysis for Indonesian context . Research This support and expand findings study previously with give proof more empirical strong about effectiveness approach inquiry in context Indonesian education.

Critical thinking ability is one of the essential 21st-century skills that students must possess to face global challenges and the rapid transformations brought by the Industrial Revolution 4.0. However, research consistently shows that Indonesian students' critical thinking skills remain relatively low, particularly in the context of science learning (Sari et al., 2023). Data from the Programme for International Student Assessment (PISA) 2018 reinforces this concern, placing Indonesia 74th out of 79 participating countries in the field of science, which highlights the urgent need for a learning approach that is capable of fostering higher-order thinking skills rather than prioritizing rote memorization or passive knowledge acquisition.

The learning approach practiced in many Indonesian schools is still predominantly teacher-centered, emphasizing the direct transfer of knowledge through lectures, note-taking, and textbook-based exercises. According to Widodo et al. (2020), such traditional instructional practices do not sufficiently stimulate students to question information, evaluate evidence, build arguments, or articulate scientific reasoning, competencies that lie at the core of critical thinking. This situation stands in contrast to the expectations of the 2013 Curriculum, which explicitly mandates the development of higher-order thinking skills, inquiry processes, and 21st-century competencies.

Among various pedagogical models, the inquiry-based learning (IBL) approach has been widely recognized at the international level as one of the most effective methods for enhancing critical thinking in science education. A recent meta-analysis by Chen and Liu (2025) demonstrated that inquiry-based learning has a significant positive effect on students' critical thinking skills with an effect size of 0.75, which is categorized as high. The inquiry approach positions students as active knowledge constructors rather than passive recipients, prompting them to formulate scientific questions, conduct investigations, analyze findings, and engage in reflective reasoning. Through cycles of questioning, experimenting, discussing, and evaluating evidence, students learn to develop scientific arguments supported by logical reasoning and empirical data.

Despite its strong theoretical and empirical foundation, the implementation of inquiry-based learning in Indonesia still faces several academic and practical challenges. A notable research gap arises from the fact that previous studies in the Indonesian context tended to examine general cognitive outcomes, without investigating in depth how each core component of inquiry (such as questioning, investigating, creating, discussing, and reflecting) contributes to the development of specific indicators of critical thinking. Furthermore, the majority of existing studies have not addressed the extent to which the inquiry approach should be contextualized to Indonesian culture and integrated with the national curriculum, including local values, learning resources, and classroom realities. Without this contextual adaptation, inquiry-based learning risks being implemented only partially or superficially, which diminishes its pedagogical impact.

Based on these gaps, this study aims to analyze the effectiveness of implementing an inquiry-based learning approach in science education to improve junior high school students' critical thinking abilities in Indonesia. The novelty of this research lies in the development of an inquiry learning model that is integrated with local wisdom and aligned with the characteristics of the Indonesian curriculum, thereby ensuring relevance to students' cultural and educational contexts. Additionally, this research employs a comprehensive and valid critical-thinking assessment instrument tailored to the Indonesian context, allowing for the measurement of students' critical thinking competencies more accurately than previous studies.

Through these contributions, this study not only supports and strengthens the findings of earlier research but also provides more robust empirical evidence regarding the effectiveness of inquiry-based learning in Indonesian science education. The outcomes are expected to offer both theoretical advancement and practical recommendations for schools, teachers, and policymakers in designing learning strategies that effectively nurture students' critical thinking skills in accordance with the demands of 21st-century education.

METHOD

Study This use Quasi-experimental design with pretest- posttest control group design. Population study is student class VIII of junior high school in Yogyakarta City, with sample as many as 120 students were selected use cluster random sampling technique from 4 schools that have characteristics similar . The samples were divided into two groups : group experiment (60 students) who received treatment learning with approach inquiry , and groups control (60 students) who received learning conventional .

Variables independent in study This is approach learning (inquiry vs conventional), whereas variables dependent is ability think critical students being measured use instrument test ability think critically developed based on indicators Ennis (2011) and has adapted For Indonesian context . Instruments This consists of of 25 questions choice double with level validity 0.78 and reliability Cronbach's Alpha 0.82.

Learning model applied inquiry refers to the 5E stages (Engage, Explore, Explain, Elaborate, Evaluate) developed by Bybee (2015) with adaptation context Indonesian culture . Every stages designed For develop components think critical includes : interpretation , analysis , evaluation , inference , explanation , and self-regulation (Facione , 2020).

Data collection was carried out through pretest and posttest use instrument test ability think critical , observation learning use sheet observation activity students , and semi- structured interviews with students and teachers. Quantitative data analyzed

using the t-test and ANCOVA with assistance of SPSS 26.0 software, while qualitative data analyzed use technique analysis thematic .

For ensure internal validity , research This control variables confounding factor like ability beginning students , background behind social economics , and teacher experience . Validity external guarded through election representative samples and natural research settings . Aspects ethics study guarded through agreement from committee university ethics and informed consent from all participants.

RESULTS AND DISCUSSION
Figure 1. Comparison of Ability Scores Think Critical between Group Experiment and Control

Group	N	Pretest M(SD)	Posttest M(SD)	Gain Score M(SD)
Experimental	60	58.3 (8.2)	78.6 (6.4)	20.3 (5.1)
Control	60	57.8 (7.9)	62.1 (8.1)	4.3 (3.2)

The t-test shows significant difference between group gain scores experimental (M = 20.3, SD = 5.1) and group control (M = 4.3, SD = 3.2), with t(118) = 19.84, p < 0.001, d = 3.75. Large effect size This indicates that approach inquiry own impact very significant practical to improvement ability think critical students (Cohen, 1988; Hattie, 2020).

Analysis Component Think Critical
Analysis more deep to components think critical show that group experiment show improvement significant in all indicators (Dewi & Sari, 2022; Thompson & Martinez, 2023). Components interpretation experience improvement highest (effect size = 1.23), followed by ability analysis (effect size = 1.18), and evaluation (effect size = 1.09). The inference and explanation components also show significant improvement with effect sizes of 0.98 and 0.95 respectively.

Table 2. Analysis Component Ability Think Critical

Component	Experimental Group	Control Group	Effect Size
Interpretation	82,4 ± 5.2	64,1±6,8	1,23
Analysis	81,7 ± 4,9	63,5±7,1	1,18
Evaluation	79,2 ± 5,6	62,8±6,9	1.09
Inference	77,8 ± 6,2	61,4±7,3	0,98
Explanation	76,5 ± 5,8	60,9±6,6	0,95
Self-regulation	74,3 ± 6,1	59,7±7,2	0,89

Learning Process Analysis
Observation learning show that student in group experiment show participation more active tall in activity learning . Average activity ask student in group experiment is 8.4 questions per session , whereas group control only 2.1 questions per session .

Activity discussion and argumentation are also more intensive in group experiments , with an average duration of discussion group 18.6 minutes compared to 6.2 minutes in the control group control .

Interview with student disclose that approach inquiry give chance more big for student For explore science concepts in general deep . As stated by one of the student : " With learning inquiry , I So more challenged For look for know Alone the answer is no only listen teacher's explanation ."

Effectiveness approach inquiry in increase ability think critical can explained through a number of mechanism theoretical . First , the approach inquiry creates cognitive conflict that encourages student For activate existing mental schemes and construct knowledge new (Piaget, 1977). Second , the questioning stage in learning inquiry practice student For develop ability analysis and evaluation to information obtained .

Context integration culture local in learning inquiry also contributes to effectiveness approach this . Use phenomenon nature and problems familiar environment for Indonesian students help increase engagement and relevance learning . This is in line with theory constructivism Vygotsky's social theory which emphasizes importance context culture in learning .

Findings study This own implications important for practice science education in Indonesia. First , the need for transformation paradigm learning from teacher- centered become student- centered through implementation approach inquiry . Second , the importance of development teacher's ability in design and implement learning based appropriate inquiry with characteristics Indonesian students.

Observational data from the learning process show that students in the experimental group demonstrated a significantly higher level of active participation during science learning activities compared to the control group. The experimental group, which experienced inquiry-based learning, asked an average of 8.4 questions per session, while students in the control group, who were taught using conventional lecture-based instruction, asked only 2.1 questions per session. The difference in participation was also reflected in the dynamics of discussion and argumentation. The experimental group engaged in an average of 18.6 minutes of collaborative discussion, more than three times longer than the 6.2 minutes recorded in the control group. These findings indicate that the inquiry-based learning approach not only increases student involvement but also creates a learning environment that supports questioning, reasoning, and peer interaction components that play a crucial role in the development of critical thinking.

Student interviews further reinforce the quantitative findings. Many students expressed that the inquiry approach provided greater opportunities to explore scientific concepts independently and deeply. As one student stated, *"With inquiry learning, I feel more challenged to find the answers by myself, not just listen to the teacher's explanation."* This testimony illustrates how the inquiry model stimulates intrinsic motivation and intellectual curiosity, encouraging students to take ownership of their learning process rather than relying solely on teacher explanations. Such ownership is a key indicator of active learning and self-regulated learning, two competencies strongly associated with higher-order thinking.

The effectiveness of inquiry-based learning in increasing critical thinking can be theoretically explained through several cognitive mechanisms. First, inquiry learning generates cognitive conflict, pushing students to re-examine and reorganize their prior knowledge, which aligns with Piaget's (1977) theory of cognitive disequilibrium leading to deeper conceptual understanding. Second, the questioning stage of inquiry requires

students to formulate essential questions, identify relevant evidence, and evaluate the credibility of information, all of which directly relate to the core components of critical thinking such as analysis, inference, and evaluation. Third, the processes of experimentation, interpretation of findings, and reasoning stimulate metacognitive reflection, enabling students to assess the accuracy and limitations of their thinking.

In this study, the integration of local cultural context into the inquiry learning design further contributed to its effectiveness. Presenting scientific investigations using natural phenomena and environmental issues that are familiar to Indonesian students increased learning relevance, emotional engagement, and personal connection to the material. This finding aligns with Vygotsky's sociocultural constructivism, which emphasizes that cognitive development is strongly influenced by social and cultural contexts. When science topics are contextualized using local realities, students are more likely to connect new scientific concepts to existing knowledge structures and to recognize the usefulness of science in everyday life.

The results of this research carry several significant implications for science education in Indonesia. First, there is a need to shift learning paradigms from teacher-centered to student-centered models, in which students become active constructors of knowledge rather than passive recipients. Inquiry-based learning is a powerful approach to facilitate this transformation. Second, the improvement of teachers' competence in designing and implementing inquiry learning should be prioritized. Teachers must be adequately trained not only in inquiry methodology but also in adapting it to the cognitive, cultural, and contextual characteristics of Indonesian students. Third, schools should provide supportive learning environments, including flexible classroom arrangements, sufficient time allocation, laboratory facilities, and collaborative learning culture to enable inquiry learning to be implemented authentically rather than superficially.

Overall, the study demonstrates that inquiry-based learning has a robust impact on enhancing students' critical thinking skills when applied systematically and contextually. By giving students the opportunity to question, investigate, reason, and reflect, science learning becomes more meaningful and effective in preparing young learners to meet the cognitive demands of the 21st century.

The following is a supporting table results findings study in topic This .

No	Article Title	Source	Research result
1	The Effect of Inquiry-Based Learning on Students' Critical Thinking Skills in Science Education: A Systematic Review and Meta-Analysis	Arifin et al. (2025)	Inquiry science- based shows effect big to think critical students (mean effect size 1.27) from 25 studies .
2	Validity and Effectiveness of Argument-Driven Inquiry Model With Contextual Approaches to Improve Critical Thinking Skills	Ms et al. (2020)	ADI model based inquiry increase N-gain thinking critical up to 0.75 (category tall).
3	The Effect of Inquiry Learning Model with STEM Approach on Students' Critical Thinking Skills	Wicaksono et al. (2024)	Inquiry model STEM- based enhance ability think critical with N-gain 0.68 (category currently).
4	Implementation of Guided Inquiry Learning Model to Improve Understanding Physics Concepts	Maknun (2020)	Inquiry guided effective increase draft physics and thinking critical vocational school

	and Critical Thinking Skills		students (N-gain 0.71).
5	Implementation of Guided Inquiry Based on Contextual Approach to Improve Students Critical Thinking Skills on Reaction Rate Material	Anjarwati & Nasrudin (2022)	Implementation inquiry based contextual increase skills think critical high school students in general significant .
6	Inquiry-Based Learning Implementation to Improve Critical Thinking of Prospective Teachers	Dewi et al. (2021)	Approach inquiry proven increase ability think critical prospective science teachers.
7	Inquiry-Creative Learning Integrated with Ethnoscience: Efforts to Encourage Prospective Science Teachers' Critical Thinking	Verawati et al. (2022)	Learning inquiry based ethnoscience increase ability think critical and understanding culture scientific .
8	Enhancement of Students' Critical Thinking Skills through Science Context-Based Inquiry Learning	Pursitasari et al. (2020)	Inquiry based the context of science increases ability analysis and evaluation critical junior high school students .
9	Implementation of an Inquiry Learning Model with Science Literacy to Improve Student Critical Thinking Skills	Sutiani et al. (2021)	Combination inquiry and scientific literacy improve think critical student up to 97%.
10	Skills Think Critical Elementary school students in Science Learning Using E-LKPD with Approach Inquiry Guided	Rohayati et al. (2023)	Inquiry with effective e-LKPD in develop skills think critical elementary school students .

Approach inquiry proven to be very effective in increase ability think critical student in science learning , as shown by various study in table . Results the consistent show improvement significant , good in a way quantitative through N-gain value as well in a way qualitative through strengthening ability analytical , evaluative , and reflective student .

Arifin et al.'s (2025) study shows meta- analysis results from 25 articles with an average effect size of 1.27, indicating that approach inquiry own influence big to think critical . This is reinforced by Ms et al. (2020) who applied *Argument-Driven Inquiry* (ADI) based context , showing an N-gain of 0.74–0.75, which is included category tall in improvement think critical .

More further , approach integrated inquiry with the STEM model as conducted by Wicaksono et al. (2024) produced an N-gain of 0.68 (category medium), shows that integration approach scientific with technology can increase results learning . Similarly , Maknun (2020) shows that inquiry guided by vocational school students can push understanding draft physics and thinking critical with N-gain result 0.71.

Anjarwati & Nasrudin (2022) emphasize on effectiveness approach inquiry based contextual , which shows success significant in material rate reaction chemistry . The same results reported by Dewi et al. (2021) shows that prospective teachers also experience improvement think critical through learning based inquiry .

Integration of approaches inquiry with mark local and cultural scientific , as done by Verawati et al. (2022) in context ethnoscience , shows that approach contextual No only increase ability think critical but also strengthens awareness culture scientific students . A similar thing was also found by Pursitasari et al. (2020) through inquiry based the context of science which is real increase ability think analytical junior high school students .

Temporary that , Sutiani et al. (2021) proved that integrated inquiry with approach scientific literacy is able increase ability think critical student up to 97% in very good category . Research Rohayati et al. (2023) also shows that implementation of e-LKPD based on inquiry guided effective used on students school base For develop ability think critical in a way comprehensive .

In a way whole , entire the above study confirm that approach inquiry , good in form guided , contextual , based technology , as well as integrated with approach other , proven effective in all level education , starting from elementary school to education prospective teacher.

CONCLUSION

Study This prove that implementation approach inquiry in effective science learning For increase ability think critical junior high school students in Indonesia. Improvement significant happens to everyone component think critical with a large effect size (d = 3.75), indicating impact very significant practical approach . inquiry proven can develop ability interpretation , analysis , evaluation , inference , explanation , and student self-regulation through questioning, investigating, creating, discussing, and reflecting activities .

Contribution theoretical study This lies in the development of learning models integrated inquiry with wisdom local and customized with characteristics Indonesian curriculum . In general practical , research This give proof strong empirical For support implementation approach inquiry in science learning in Indonesia as alternative from learning conventional which is still dominant .

Limitations study This covering duration relative research short (12 weeks) and focused on the eyes science lessons only . Research furthermore recommended For study effectiveness approach inquiry in term long and on the eyes other lessons , as well as analyze moderating factors that influence effectiveness approach This in context Indonesian education.

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