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| RESEARCH ARTICLE

Development of Guided Inquiry Learning Model Based on Critical Questions to Improve Critical Thinking on the Concept of Temperature and Heat

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| ABSTRACT
Conducting at the VII grade in SMPN 1 Batudaa, SMPN 2 Batudaa, and SMP Muhammadiyah Batudaa, this study aimed to develop and describe the quality of the critical question-based guided inquiry learning model in order to improve students' critical thinking skills on the concepts of temperature and heat. The development method used is Research and Development with a 4D development model, namely define, design, development, and disseminate. The results of this study indicated that: 1) the validation of the guided inquiry learning model based on critical questions is declared valid with minor revisions, 2) the practicality of the learning model is determined by the average percentage of learning implementation that gets a very good category throughout the trial class and the teacher's response model and response. Students obtained through questionnaires gave a positive response, 3) the effectiveness of the learning model was determined through the average percentage of student activities obtained in the active and very active categories; meanwhile, the results of the critical thinking skills test obtained the completeness of the average posttest score with a very good category with high N-gain analysis (<g> 0.7), an increase in critical thinking skills in students is evidenced by an increase in the average value from pretest to posttest on each critical thinking indicator with high N-gain analysis. Based on the results of this study, it was concluded that science learning using the Guided Inquiry learning model based on Critical Questions had met the valid, practical, and effective criteria for improving students' thinking skills.

| KEYWORDS

Development, Learning Models, Guided Inquiry, Critical Thinking, Critical Questions, Valid, Practical, Effective

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1. Introduction

Education in Indonesia continues to develop, given that the role of education is to form quality human resources by utilizing appropriate learning methods. Learning Model is a pattern planning that can be used to design face-to-face learning in the classroom and tutorials and form a learning device (Joice & Weil, 2000). In addition, variations in learning models can affect learners' learning enthusiasm, avoid boredom, and promote motivation in following the learning process.

In learning, science subjects are lessons that students must master. In line with this notion, Yuniarti (2018) contends that Science Education can assist students in building understanding and thinking habits as well as life skills, such as observation, scientific attitude, and prediction. According to Curriculum 2013, science learning should be carried out in a scientific inquiry, which was first developed by Richard Suchman in 1962 (Joyce, 2000). This method aims to help learners develop intellectual thinking skills and other skills, such as asking questions and finding solutions that stem from learners' curiosity. This statement corresponds with Joyce (2000), who expressed that "The general goal of inquiry training is to help students develop the intellectual discipline and skills necessary to raise questions and search out answers stemming from their curiosity". Rooted deeply in the inquiry learning

method, students are mentally and physically engaged in solving problems set by the teacher, and subsequently, students will be conscientious, tenacious, objective, innovative, and respectful of others' viewpoints.

In terms of science learning, observations revealed that learning is more focused on teachers, leading students to become passive as a result of a lack of opportunities to gain knowledge, lack of learning motivation, and poor critical thinking skills. In addition, due to outside school activities, the discussion with the relevant science teacher showed that the learning approach utilized is a conventional learning model. On the contrary, the 2013 curriculum explained that science should be implemented with high-level thinking learning, one of which is critical thinking. High-level thinking learning is learning where learners are more active in analyzing, discussing, and solving problems linked to science material. Therefore, the researcher aims to develop and describe the learning model of critical question-based guided inquiry to improve learners' critical thinking skills.

2. Literature Review

2.1. Guided Inquiry Learning Model

According to the definition above, a learning model is based on a more specific approach to a concept and learning objectives, such as a model devoted to science teaching to enhance critical thinking, thinking skills, and concept understanding. As previously said, Joice and Weil (1992) defined a learning model as a pattern planning that can be used to create face-to-face learning in the classroom and tutorial and to form a learning device. Joice and Weil further stated that a successful learning model should have five main elements, including syntax, social system, reaction principle, support system, teaching, and nurturant effect. A structure of a certain model depicts the sequence of activities required for teaching and learning. The social system identifies the roles and relationships between teachers, students, and the advocated types of norms (rules). Additionally, the role of teacher leadership in each learning model is different. This reaction principle is related to how teachers pay attention to and treat students, including the way teachers respond to questions, replies, responses, or what students do. A learning model's support system includes all of the resources, materials, and tools required for implementing the model. Instructional effect reflects a learning outcome that is directly achieved by guiding learners to the desired goals. The nurturant effect, on the other hand, is a learning outcome that occurs as a result of the establishment of a learning atmosphere that the learners experience directly without direction from the teacher.

The term inquiry means "question" or "investigation". Inquiry learning was firstly developed by Richard Suchman in 1962 (Joyce, 2000), and its purpose is to aid learners in cultivating intellectual thinking skills and other skills such as asking questions and finding answers that originated from learners' curiosity. By learning with the inquiry method, learners are involved mentally and physically in solving the problems given by the teacher. Thus, students will be accustomed to behaving with a scientific attitude that is thorough, diligent/tenacious, objective/honest, respect the opinions of others, and creative.

The term inquiry can be translated as "query" or "investigation." Richard Suchman first developed inquiry learning in 1962 (Joyce, 2000). The aim of inquiry learning is to assist students in developing intellectual thinking skills and other skills such as asking questions and discovering solutions that arise from their curiosity. Learners are mentally and physically engaged when using the inquiry technique to answer problems presented by the teacher. As such, students will be diligent/tenacious, objective/honest, innovative, and appreciative of others' perspectives.

Based on the previous explanation, teachers are required to develop students' knowledge and capability of thinking, including critical thinking, which can be cultivated through critical questions. Critical questions at a high cognitive level (*high-level question*s) are expected to encourage learners to train their ability to think critically. Table 1 below shows some instances of questions according to Facione (2011):

Table 1. Questions to Stimulate Critical Thinking

No.	Indicator	Questions
1	Interpretation	What does it mean? What happened? What is the best way to characterize/classify/classify?
2	Analysis	What does that mean? Give a reason for the statement! What makes you think so? What is your basis for saying it?
3	Conclusion	What conclusions can we draw? What prevention can we do? What are the consequences of doing so?
4	Evaluate	How reliable is the statement? Do we have the right facts?

		How reliable is this conclusion?
		What are the specific findings of this study?
		Explain your conclusions from that analysis!
5	Explanation	How do you interpret it?
		Explain your reason for it!
		How would you explain why this decision was made?
		Our understanding of this issue is not clear; can we practice again?
6	Self-Regulation	How good is our methodology, and how do we follow it?
		How reliable is the evidence we have?
		This decision is still confusing; can we explain it again before we make the conclusion?

(Sources: Facione, 2011)

In addition, there are standard questions that should be examined to develop learners' critical thinking abilities. Table 2 below is a list of eight standard questions presented by Paul & Elder in order to upgrade critical thinking (Philosophy, 2008).

Table 2. Standard Questions to Improve Critical Thinking

No.	Standard	Questions
1.	Clarity	Can you elaborate further?
		Can you give me an example?
		How can we check that?
2.	Accuracy	How do we know if that is true?
		How can we verify that?
		Can you be more specific?
3.	Precision	Can you give a more detailed explanation?
		Can you be more detailed?
		How does it have to do with the problem?
4.	Relevance	How does it have any relation to the question?
		How can it solve the issue?
		What factors make this a difficult problem?
5.	The depth	What is the complexity of this question?
		What are the difficulties we need to solve?
		Do you need to look at this from another perspective?
6.	Vastness	Do you need to consider another point of view?
		Do you need to look at this from another method?
		Does all this produce an understanding?
7.	Logic	Does your first paragraph match the last paragraph?
		Is what you said factual?
8.	Significance	Is this the most important issue to consider?
		Is this the main idea that deserves recognition?

Sources: Paul & Elder (in Filsaisme, 2008)

In critical thinking, several indicators are divided into 5 groups (Ennis in Costa, 1985), including, (1) Provide a simple explanation, (2) Build basic support, (3) Make inference, (4) Make an advanced clarification, (5) Set strategies and tactics. These five indicators of critical thinking skills are further outlined in Table 3.

Table 3. Critical Thinking Skills Indicators According to Ennis

NO.	Critical Thinking Skills	Sub Critical Thinking Skills	Explanation
1.	Simple explanation	1. Focusing questions	a. Identifying or formulating questions
			b. Identifying criteria for considering answers that might
			c. Maintain a state of mind
		2. Analyzing arguments	a. Identifying conclusions
			b. Identifying reasons (causes) stated (explicit)
			c. Identifying reasons (causes) that are not expressed (implicit)

NO.	Critical Thinking Skills	Sub Critical Thinking Skills	Explanation
			d. Identifying relevancy and irrelevancy e. Looking for similarities and differences f. Looking for the structure of an argument g. Summarizing
		3. Ask and answer clarifying questions and challenging questions	a. Why b. What is the point? What does it mean c. What is the example? What is nonexample d. How to apply it in the case e. What made the difference f. Will you state more than that
2.	Basic support	4. Considering credibility (criteria of a source)	a. Expert b. Absence of conflict of interest c. Agreement between authorities d. Reputation e. Using existing procedures f. Knowing the risk g. Ability to deliver reason h. Habit of caution
		5. Observing and considering the results	a. Involved in concluding b. Reported by the observer c. Recorded the desired things d. Reinforcement *(corroboration)* and the possibility of strengthening e. The conditions of good access f. Competent use of technology g. Observer satisfaction of credibility criteria
3.	Inference	6. Make a deduction and consider the results	a. Logical group b. Logical conditions c. Interpretation statement
		7. Making induction and considering induction	a. Making generalizations b. Making conclusions and hypotheses
		8. Make and consider the value of decisions	a. Background facts b. Consequences c. Principles implementation d. Thinking of alternatives e. Balancing, deciding
4.	Advanced clarification	9. Defining the term, considering the definition	There are three dimensions: a. Form: synonyms, classification, range, same expression, operational, examples, and non-examples b. Definition strategy (action, identifying equations) c. Content
		10. Identifying assumption	a. Implicit reasoning b. Assumptions necessary assumptions, reconstruction of the argument
5	Strategies and tactics	11. Deciding an action	a. Defines a problem b. Selecting criteria to make solutions c. Formulating possibility alternatives d. Deciding things to be done tentatively e. Reviewing f. Monitoring implementation
		12. Interact with others	

Sources: Ennis (in Costa, 1985)

In terms of science learning, the above indicators are further detailed; thus, the appropriate and specific indicators for science are obtained as follows: (1) formulating/identifying questions, (2) Drawing conclusions, identifying stated reasons, identifying unstated reasons, find similarities and differences, identify relevant matters, find structures/formulas, summarize. (3) Responding to the following questions: what are the cause, the main reason, and the fact. (4) Adapting to the source, providing reasons, and cautious behaviors (5) Reporting based on observation, reporting on the generalization of experiments, reinforcing ideas, conditioning positive behaviors (6) Making inquiries. (7) Generalizing, research. (8) Applying principles or formulas, considering alternatives. (9) Determinate a strategy and specify the subject matter definition. (10) Identifying assumptions based on non-expressed causes and construct statements. (11) Formulating problems, selecting criteria to consider solutions, developing alternative answers, determining tentative decisions, summarizing by assessing the situation, and making a decision. (12) employing logical methods.

3. Research Methods

The study is development research in the field of education since it focuses on developing a critical question-based inquiry learning model to increase critical thinking on the concept of temperature and heat in Science Learning. The *Four D* development model is applied in this study; those are define, design, development, and disseminate. The quantitative descriptive approach will result in a product in the form of learning model books and learning tools, namely: 1) Syllabus, 2) Lesson Plan *(RPP)*, And 3) Students Worksheet *(LKPD)*, 4) Teaching Materials, 5) Critical Thinking Skills Test on temperature and heat materials. The types of data obtained in this study are qualitative data and quantitative data. Quantitative data are obtained from validity results, practicality, effectiveness, and students' response, as well as the development of learning models, qualitative data, by contrast, are derived from the results of questionnaires to determine what factors that support and inhibit the application of the critical question-based guided inquiry learning model. The instruments used for data collection are the instrument validity of the learning model book, the instrument practicality of the learning model, the instrument effectiveness of the learning model, and the instrument characteristics of the learning model guided inquiry-based on critical questions. The data analysis technique in this study is quantitative description analysis, and it was conducted using descriptive statistical analysis. Descriptive statistics are used to describe data in the form of percentages and to explain the data or events with explanatory words.

4. Results and Discussion

The results of the development of a critical question-based guided inquiry learning model hinge upon the 4D development model, entailing four stages, such as to define, design, development, and dissemination. The *define* stage in the analysis findings comprises five activities: early-final analysis, students analysis, task analysis, concept analysis, and learning goal formulation activities. The next stage is *design,* which is the stage of preparing the initial design of the critical question-based guided inquiry learning model. Following the design stage is the development stage, in which the development to produce products through experts and trials is performed in this stage. The final stage is the dissemination or deployment stage, where the 4D development model is leveraged. The study findings are in the form of articles and books guided inquiry learning model based on critical questions socialized through the Teachers Network Program *(*MGMP*)* of Science subject in SMP junior high schools throughout Batuda'a District, Gorontalo Regency, Gorontalo Province. The teacher members are Science teachers from SMP junior high school Muhammadiyah, SMP 1 and SMP 2 state junior high school Batudaa. The quality of the critical question-based guided inquiry learning model is determined by the practicality and effectiveness of the critical question-based guided inquiry learning model obtained from the results of limited and holistic trials. Following are descriptions of the practicality and effectiveness of the findings of limited and holistic trials:

4.1. Effectiveness of the Critical Question-Based Guided Inquiry Learning Model Limited Trials

Learners' critical thinking skills data are obtained from the pretest and posttest results. In the pretest-posttest test, learners are required to complete 10 items of test questions description. The pretest is given prior to treatment, while the posttest is administered after treatment. The treatment given is in the form of the application of a guided inquiry learning model based on critical questions. Here are the findings of the learners in the limited trial class's critical thinking skills test.

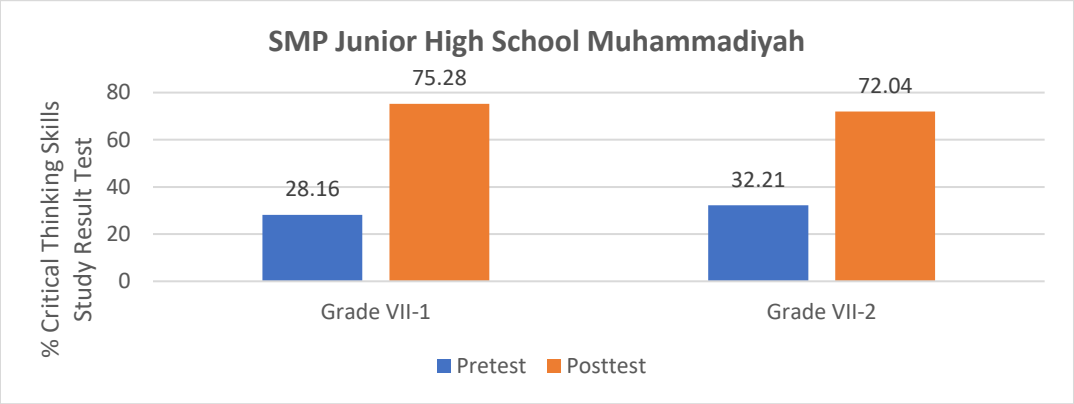

Figure 1. Pretest and Posttest Score Percentages in Limited Trial Classes

Based on Figure 1, it can be seen that there was an increase in learning outcomes from pretest to posttest, where in Class VII 1, the result increased by 47.1%, and in Class VII 2, the result increased by 39.8 %. Therefore, the use of the critical question-based guided inquiry learning model in science learning is effective to be implemented in limited trials in terms of critical thinking skills test results, particularly on the idea of temperature and heat.

4.2. The Effectiveness of the Critical Question-Based Guided Inquiry Learning Model Holistic Trials

Critical thinking learners derived data learning outcomes from pretest and posttest data. Learners must complete 10 test question descriptions as part of the pretest-posttest. The initial test (*Pretest*) is given before treatment, and the final test (Posttest) is given after treatment. The treatment consists of implementing a guided inquiry learning methodology based on critical questions. The average value of pretest and posttests in the holistic trial class is as follows.

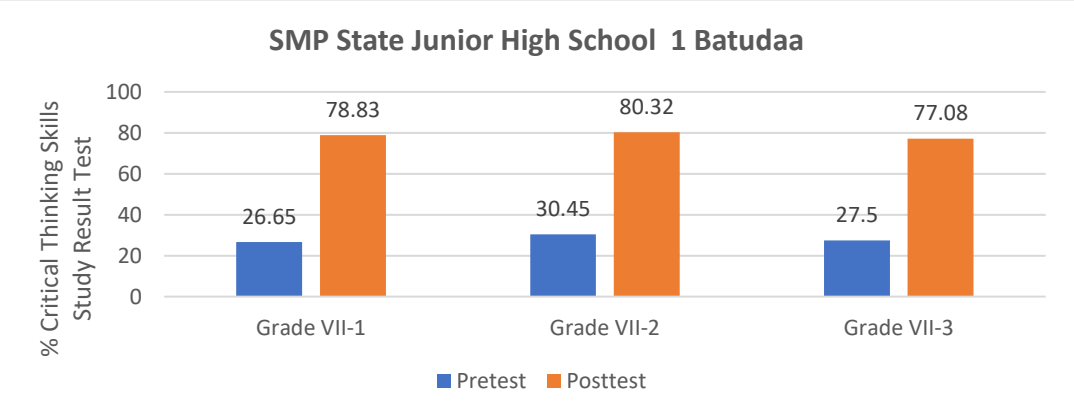

Figure 2. Pretest and Posttest Score Percentage in the Holistic Trial Class in SMP 1 State Junior High School Batudaa

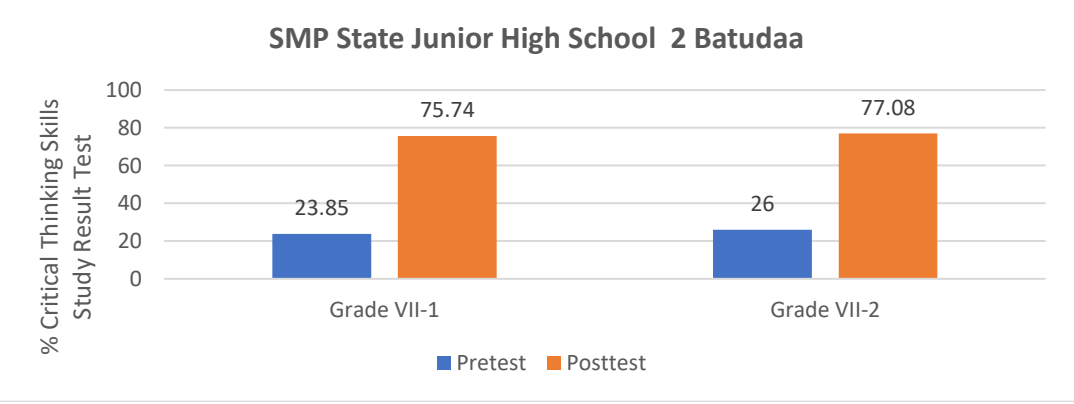

Figure 3. Pretest and Posttest Score in the Holistic Trial Class in SMP 2 Junior High School Batudaa

Based on the holistic trial class results found in the students' critical thinking skills test conducted in five classes of SMP 1 and SMP 2 Batudaa, suffice to say that the application of the learning model guided inquiry-based on critical questions is effective in terms of aspects of learning outcomes heat.

As previously explained, the process of developing a critical question-based guided inquiry learning model has run through four stages of 4D development, such as *to define*, *design*, *development*, and *dissemination*. The learning model was developed to address the problems that emerged in the observations from SMP Junior High School in the Batudaa District environment. Following is a discussion of each development stage: (1) At the *define* stage, it is concluded that the development of the model of learning inquiry-based guided critical questions is considered necessary as one of the efforts to provide solutions to the identified issues. (2) at the *design* stage, the researcher prepares the initial design for the development of a critical question-based guided inquiry learning model. In the design process of the learning model researcher refers to the opinion of Joice and Weil, who argue that there are five main elements as a character in a good learning model. The five elements are structure, social system, reaction principle, support system, teaching, and norturant impact. The design process at this stage resulted in a book-guided inquiry learning model based on critical questions. (3) Next is the development stage or product design development stage. Validation of the basic design of the critical question-based guided inquiry learning model is carried out by three experts. Learning model books and learning tools are examples of validated designs. The validation of the learning model book includes content validation and learning model construction validation, whereas the validation of learning tools includes syllabus validation, lesson plan, teaching materials, LKPD, and learners' critical thinking skills tests. (4) Then, in the development of a critical question-based inquiry learning model through the discussion of MGMP Science in junior high schools in Batudaa District, Gorontalo Province, the research results were disseminated in the form of articles and books aforementioned. Science teachers from SMP Muhammadiyah, SMPN 1 Batudaa, and SMPN 2 Batudaa are members. The teacher members are from SMP junior high school Muhammadiyah, SMP 1, and SMPN 2 State Junior high school Batudaa.

After analyzing the learning model development process, the researcher examined the quality of the learning model, which is linked to the practicality and effectiveness of learning models based on limited and holistic trials. Both the limited trial and the holistic trial showed positive results, and the employment of a critical question-based guided inquiry learning model in both trial classes met the model's practicality criteria.

5. Conclusion

This study aimed to develop and describe the quality of the critical question-based guided inquiry learning model in order to improve students' critical thinking skills on the concepts of temperature and heat. Based on the findings and analyses of the development of a critical question-based guided inquiry learning model, it can be concluded that the guided inquiry learning model has proven to be beneficial in improving students' comprehension of temperature and heat. Furthermore, researchers recommend that teachers should have the skills to motivate students and pay attention to how time should be allocated. In addition, the guided inquiry learning model based on critical questions should be utilized as an alternative to promote critical thinking activities and outcomes in Integrated Science disciplines. As the discussion is only limited to the concept of heat and temperature, further studies should be conducted on different topics.

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