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IMPROVEMENT OF STUDENTS CRITICAL THINKING SKILLS THROUGH STRUCTURED INQUIRY LEARNING MODELS ON SUBSTANCE PRESSURE TOPICS

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Abstract: The study aimed to describe improving students' critical thinking skills by applying a structured inquiry model to the substance pressure topic. The research design is one group pretest-posttest design. The study was conducted at the eighth-grade junior high schools in Surabaya in the 2021/2022 academic year, which totaled 22 respondents. Data collection techniques in questionnaire and test. The questionnaire analysis used the Guttman scale, which was calculated using the percentage formula. While the data analysis techniques pretest-posttest using N-Gain score, normality test, and paired t-test. An implementation of the structured inquiry model improves students' critical thinking skills. It is shown that the t-test where the significance value of (0.000 <0.05) indicates differences in students' critical thinking skills before and after the structured inquiry model is applied. The average value of Gain evidence the difference-the results were (0.81) in the high category, and 91% of the 22 students experienced increased critical thinking skills in the high category. The implementation of learning using the inquiry model gets a mode value of 4, so it can be categorized as very good. The students gave a response reaching 93.96% in the very good category. In conclusion, a structured inquiry model can improve students' critical thinking skills on substance-pressure topics.

Keywords: *Critical Thinking Skills, Structured Inquiry, Substance Pressure*

INTRODUCTION

21st-century education requires the student to have the intelligence, knowledge, and skills needed to face an increasingly advanced era in the era of globalization [1]. However, the skills needed are not only reading, writing, arithmetic, and memorizing skills. Skills that must be developed are high-order thinking, one of which is critical thinking skills. These critical thinking skills need to be trained in learning to strengthen students' conceptual understanding by enriching real and meaningful experiences [2]. Students with high critical thinking tend to be more competent than those who are less critical [3]. Based on the description above, it can be interpreted that critical thinking skills are not naturally possessed by students, so they need to be trained and developed in the learning process. Therefore, teachers must be able to adapt and prepare innovative learning models in the face of the times and use an appropriate curriculum.

Since 2013 Indonesia has set critical thinking as a learning goal by implementing the 2013 curriculum [4]. It is in line with learning and curriculum authorities in several developed countries who place critical thinking skills in their curriculum as a learning goal [5] and educational standards such as in Canada, Europe, New Zealand, and the United States of America [6]. The 2013 curriculum used in Indonesia has accommodated 21st-century skills both from the use of assessment standards, content standards, and process standards. The problem is that most child-centered learning has not been implemented, so students do not master 21st-century skills optimally [7].

Research on junior high school science learning states that an efficient solution to overcome students' low level of critical thinking is to use an inquiry model, where students get the opportunity to be directly involved in experimental activities to get answers to problems [8]. The inquiry learning model is also used in learning abstract physics concepts. The results of this study are learning devices using an inquiry model with a scientific work approach can improve students' critical thinking on static electricity material [9]. Previous research in class VIII at a private school in Toraja showed that learning with the help of a structured inquiry model improved students' critical thinking skills [10, 11]. Based on the research results above, students' critical thinking skills can be effectively improved using a structured inquiry learning model.

However, the results of observations at the junior high school in Surabaya show that during the implementation of learning, especially science material in the field of physics, which is often related to formulas, numbers, and other arithmetic operations, they still use the lecture method and do not provide opportunities for students to conduct investigations both in the laboratory and surrounding environment. Therefore, students do not like the subject matter of physics. It cannot support the development of critical thinking skills. During the learning process, students are expected to be able to channel their critical thinking into formulating solutions to the problems given. However, there are still few who do. In addition, educators are more focused on delivering material than allowing students to think.

Based on the problems above, efforts are needed to overcome students' low critical thinking skills. The success of learning objectives is supported by educators' role in using models, methods, and learning approaches that follow the learning process [12]. Good teaching can teach material through direct and contextual experience to build knowledge [13]. The structured inquiry learning model can be used as a solution to improving students' critical thinking skills optimally. The inquiry learning model is divided into four levels based on the complexity of the application [14]. This study uses one level of inquiry, namely structured inquiry, with four learning phases: experiments and concluding [15]. Syntax analyzes experimental data and concludes structured inquiry learning emphasizes the activeness of students' ability to guide students to practice critical thinking skills during learning activities [16].

Structured inquiry is a learning model that provides direct experience by conducting investigations to find evidence to answer the problems presented [17]. The teacher provides several problems for students to solve, prepares tools and materials, and explains the experimental procedures to be carried out. This study uses structured inquiry because, in the age range of 12-15 years, students tend to like to play and have never designed a practicum procedure, so their skills are inadequate; in this case, teacher guidance is needed [18]. This description is in line with Vygotsky's theory of constructivism, where the environmental situation strongly influences students' knowledge during learning. It means that complex thinking processes are highly dependent on interactions between educators and students to provide in-depth understanding. As students discuss problems with more knowledgeable educators, gradually, the assistance from these educators will help construct knowledge and become part of students' thinking structure [19]. Based on the description above, it can be interpreted that in the structured inquiry model, educators are used as companions for students in learning, conduct investigations, and as a facilitator in guiding during the learning process.

This research is important to do to help improve students' critical thinking skills and help improve the quality of learning in schools by providing innovations for educators in implementing learning that involves the active role of students. The difference between this research and previous research lies in the critical thinking indicators used. In previous studies, the indicators of critical thinking skills that became the research focus were analyzing, providing logical arguments, and testing data. Meanwhile, this study uses the basic elements of critical thinking skills according to Ennis's view, which is translated into six sub-indicators of critical thinking, namely 1) proposing hypotheses, 2) writing experimental results, 3) providing further explanations, 4) formulating alternative solutions, 5) determine an action to solve the problem, and 6) conclude from the results of the investigation [20]. Using these indicators is expected to train students' critical thinking after learning to analyze well, explain logically, and act by conducting experiments so that they can provide appropriate solutions to the problems given based on factual data obtained through experimental activities.

RESEARCH METHODS

One group pretest-posttest design was used to design research [21]. This study only used one test class with two tests before and after treatment using a structured inquiry model. Improved critical thinking skills can be seen by comparing the data analysis results in the pretest and posttest [22]. All students in one class with 22 children were used as research subjects.

The study lasted two weeks, starting from January 12 to 26, 2022, with five meetings during the COVID-19 pandemic, so learning time was limited. This research has four stages, starting with giving critical thinking skills test questions before being given treatment. Furthermore, the treatment was in the form of applying a structured inquiry model to the material pressure of substances which was carried out three times in practicum. The third stage is giving test questions after treatment, and the last stage is to analyze the results of the critical thinking skills test using a structured inquiry model.

The test method measured improving critical thinking skills based on critical thinking indicators. Meanwhile, the response questionnaire was prepared using the Guttman scale to assess student responses after the structured inquiry learning model was applied.

The instruments are student response questionnaires and tests of pretest and posttest, which had previously been validated by experts from the UNESA FMIPA Science Education Study Program. Based on the results of the three validators, in general, the instrument used is said to be valid with a score of 4, so it can be categorized into very valid criteria using the calculation of the mode value. The instrument's assessment and determining the instrument's feasibility are assessed on a scale of 1 to 4 [23].

The data assessment technique uses quantitative descriptive analysis, a research method to observe and describe the numerical data collected to conclude a phenomenon under study [24]. The results were pretest-posttest tested using normality test and paired t-test. The normality test is used as a requirement before the parametric test to detect the distribution of the data to be used in the study. While the test in measuring the hypothesis to answer the research problem formulation using paired t-test. The data from the test assessment results were also analyzed using the N-gain test, which was intended to detect how much-improved students' critical thinking skills were. The results of the score from the calculation are interpreted in Table 1.

Table 1. Normalized Gain Criteria

Normalized Gain Value	Interpretation
$0.70 \leq$ N-Gain ≤ 1.00	High
$0.30 \leq$ N-Gain < 0.70	Moderate
$0.00 <$ N-Gain < 0.30	Low

[25]

While the scoring of the response questionnaire was designed using the Guttman scale, as shown in Table 2.

Table 2. Guttman Scale Rating

Answers	Score
Yes	1
Not	0

The results of the response data were then analyzed using the percentage formula,

$$\% \text{ Student response} = \frac{\text{Total score "yes"}}{\text{Total number of indicators}} \times 100\%$$

The resulting data is then interpreted in the following Table 3.

Table 3. Response Criteria on Questionnaire

Response	Criteria
0-20 %	Very Less
21-40 %	Less
41-60 %	Enough
61-80 %	Good
81-100 %	Very Good

RESULT AND DISCUSSION

The research was conducted to describe the improvement of students' critical thinking skills using a structured inquiry model on the material pressure of substances. The research results obtained are: 1) the results of observations of the implementation of learning, 2) the results of improving the skills of students, and 3) the results of the student response questionnaire. The research was carried out through 3 trials. The first experiment was on Archimedes' Law, followed by the Hydrostatic Pressure experiment, and the last was an experiment on Gas Pressure.

The learning process can run effectively with the help of teachers in directing, guiding, and motivating students [26]. In line with that, teacher assistance through a structured inquiry model has been proven to influence scientific investigations so that students can use their critical thinking in solving problems and achieving learning goals [27].

The structured inquiry phase has a relationship with critical thinking indicators to support improving students' critical thinking skills. The first phase of structured inquiry is the identification of questions. In this phase, the educator gives students a question or problem formulation to direct their thoughts to the purpose of the experiment. Students discuss with their groups to connect the illustrations with the problem formulation. Students can ask the teacher if they have difficulty understanding to get an explanation. Students begin to think of answers temporary or hypotheses, where putting forward a hypothesis is the first indicator of critical thinking. To discover whether the hypothesis is true, students continue their investigation in the second phase of the structured inquiry by conducting experiments. Students will explore to get evidence and references related to the problems and then write experimental results. After getting the experimental results, data analysis is the next structured inquiry phase. Students analyze the experimental results logically and systematically, which are linked to existing theories. The educator becomes a facilitator who checks the results of the student's analysis to determine whether it is correct and there are no misconceptions. This analysis phase also helps students with indicators, provides further explanations, and provides alternative solutions to solve problems. The last phase of structured inquiry is making conclusions from the experimental results. In this phase, students are trained to conclude learning outcomes written on the worksheet. The conclusions from the investigation results also help students determine an action in solving problems.

This study uses a description test in the form of story questions which aims to enable students to do more analysis. This opinion is in line with the fact that story questions are one element of problem-solving that can help sharpen the brain to develop critical thinking from the analysis process [28].

Data pretest and posttest, the research results obtained were then tested for normality using the software Statistical Package for The Social Science (SPSS) 25 for windows. The results obtained are as follows:

Table 4. Normality Test Results One- Sample Kolmogorov-Smirnov Test

N (Number of students)	Asymp. Sig (2-tailed)
36	0.200

Kolmogrov-Smirnovused as a normality test. The data is said to be normally distributed if the significance value is greater than (0.05), so it can be continued to the paired t-test [29]. Based on the table of research results, the significance value is (0.200>0.05), so the data is said to be normal.

The prerequisite test has been met; then, the parametric statistical hypothesis testing can be continued using the paired t-test. This test is used to determine whether there are differences in students' critical thinking skills before and after learning using a structured inquiry model (Table 5).

Based on the paired t-test in Table 5, the pretest and posttest results show that the significance value is (0.000) or less than (0.05). It means an increase in

critical thinking skills through a structured inquiry model on the substance pressure material.

The test results were also analyzed using N-Gain to measure how much-improved students' critical thinking skills were. The data from the N-Gain analysis of critical thinking skills is presented in Figure 1.

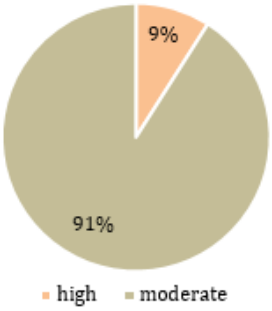

Figure 1. Critical Thinking Skills Improvement Diagram

The results showed that 91% of the 22 students had high critical thinking skills, and the rest were moderate. Based on the data from the N-Gain test results shown in the figure, there are no students with an increase in the low category.

Category differences in students' critical thinking can be influenced by factors such as the condition of the students and the environmental conditions of the students, as well as the abilities of the students themselves [30]

In detail, the acquisition N-Gain values based on indicators of critical thinking skills can be seen through the data recapitulation pretest and posttest results in Table 6.

Based on the table 6, the average score of pretest and posttest on each critical thinking indicator. After knowing the maximum score and the average score of the pretest-posttest then calculated using the N-Gain formula. The table above shows that critical thinking skills increased with an average score in the high category. The N-Gain value of 0.92 was obtained on the indicator, suggesting a hypothesis that indicates the indicator is in the high category. The indicator writes the experimental results to get an N-Gain value of 0.86 in the high category. Furthermore, the indicator concludes the investigation results, which are also in the high category with an N-Gain value that is not far from the previous indicator, which is 0.85. The indicator for formulating alternative solutions is different from the previous three indicators where in this indicator, students have little difficulty doing the test, so the resulting N-Gain value is 0.63 in the medium category. The last two indicators, namely acting by providing further explanation and determining an action to solve a problem, are both in the high category with N-Gain values of 0.78 and 0.83, respectively. It can be seen that the indicator stating the hypothesis has the highest N-Gain value, while the indicator formulating alternative solutions has the lowest N-Gain value.

Table 5. Test Results t- Paired (Paired Sample Test)

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pretest-Posttest	-47.77273	14.47471	3.08602	-52.19056	-39.35500	-14.832	21	0.000

Table 6. N-Gain Each Critical Thinking Skills Indicator

No	Critical Thinking Skills Indicator	Maximum A score of Each Indikator	Average Pretest Score	Average Pretest Score	N-Gain	Gain Categories
1	Putting forward a hypothesis	15	8	14.5	0.92	High
2	Write test results	15	8.6	14.1	0.86	High
3	Drawing conclusions from the result	15	6.9	13.8	0.85	High
4	Formulate alternative solusions	20	7.3	15.4	0.63	Moderate
5	Act by providing further explanation	20	13.1	18.5	0.78	High
6	Determine an action to solve a problem	15	8.2	13.9	0.83	High

The indicator formulated an alternative solution to get the lowest N-Gain value among other indicators and fall into the medium category. These results align with research that shows that indicators of formulating alternative solutions are at the lowest level among other indicators [31]. The low value generated in the indicators formulating alternative solutions is because the indicators are included in the 6th level of bloom taxonomy, where the 6th level is the most difficult level among other levels [32]. At this level, students assess existing theories by considering the analysis results to make policies in

providing solutions to solve problems [33]. Based on previous learning, students only listen to the material without working actively during the learning. It makes students accustomed to being passive and only relying on past events as clues in making decisions. The lack of knowledge and experience possessed by students affects analytical activities to make alternative solutions to solving problems. It is in line with the opinion. A person must understand to be able to make decisions in providing problem solutions and apply, analyze and synthesize the problems at hand [34].

Critical thinking skills do not happen by chance, but all of that happens with structured, deliberate, and repeated explanations by students to develop deep thinking [35]. It can be supported by using a structured inquiry model that actively involves students during investigations in the learning process. Thinking critically allows students to analyze or look for evidence following the facts or the truth [36]. People with critical thinking skills can ask questions correctly, combine and reduce relevant information, think logically about the information they get, and make reliable conclusions. Critical thinking skills are needed for daily activities and also affect students' academic and professional success [37].

Table 7. Student Response Results Recapitulation

Statement Number	Response (%)		Criteria
	Yes	Not	
1	100	0.00	Very Good
2	90.91	9.09	Very Good
3	86.63	13.37	Very Good
4	81.82	18.18	Very Good
5	95.45	4.55	Very Good
6	100	0.00	Very Good
7	95.45	4.55	Very Good
8	81.82	18.18	Very Good
9	100	0.00	Very Good
10	100	0.00	Very Good
11	77,27	22.73	Good
12	100	0.00	Very Good
13	100	0.00	Very Good
14	100	0.00	Very Good
15	100	0.00	Very Good

The student response questionnaire sheet contains statements about aspects that make students more independent, motivated, and active and understand the presented material. Collecting student response questionnaire data is distributed through the paper that is filled out independently and manually following the students' opinions. The results of the student response questionnaire are based on the experience of students after the implementation of the structured inquiry learning model. The questionnaire was compiled based on the provisions of the Guttman scale, which consists of 15 statement items using a score range of 0-1, where the response "Yes" gets a score of 1 while the response "No" gets a score of 0, which is then calculated using the percentage calculation according to Table 7.

Based on the table above, the average student response is 93.96%, indicating that the students responded well. The table above shows that students are enthusiastic and positively react to learning the material pressure of substances using a structured inquiry model. The inquiry model gives a pleasant impression, so students are motivated to learn and can work together in discussion groups. It follows Piaget's theory, where good pedagogy must involve students by conducting experiments. The theory represents constructivism which views cognitive as a process in which students actively construct systems of meaning and understanding of reality through their experiences and interactions [38].

CONCLUSION

Based on the result of the research, there is an increase in critical thinking skills through a structured inquiry model, as evidenced by the paired t-test results that the significance value is (0.000 <0.05), which means that there are differences in critical thinking skills before and after the structured inquiry model is applied. The difference score of N-Gain was obtained at 0.81 in the high category, and as many as 91% of the 22 students experienced increased critical thinking skills in the high category. This research is concluded to improve students' critical thinking skills through structured inquiry learning on substance pressure materials.

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