

Analysis of Students' Critical Thinking Skills through Problem-Based Learning Approach Using HOTS Questions in SMA N 13 Medan

Fristita Desania, Bornok Sinaga, Asrin Lubis, Edi Syahputra

Abstract— This study aims to describe students' critical thinking skills using problem-based learning approach assisted by HOTS questions. This research was conducted at SMA Negeri 13 Medan odd semester 2019/2020. The data collection technique was performed using a test of 5 questions that refer to indicators of students' critical thinking skills. Based on the results of the study obtained students' critical thinking skills in linear systems with three variables in class X MIA₂ 2019/2020 with students' mean score of 71, which is included in the medium category.

Index Terms : Critical Thinking Skills, Problem Based Learning, HOTS

1. INTRODUCTION

Education is a system consisting of inputs, processes, and outputs [1]. Education can change one's mindset to create innovations and improvements in all aspects of life towards quality education [2]. As stated by [3], education is a conscious and planned effort to create an atmosphere of teaching and learning process so that students actively develop their potential to possess religious and spiritual strength, self-control, personality, intelligence, noble character, and skills needed for themselves, society and nation. Education is one of the main pillars to anticipate the future, education is always oriented to preparing students to play a significant role in the future [4]. Therefore, it is important to pay attention to the progress of education in this country. Education is necessary to create the next generation of this country that is qualified and skillful. The statement is supported by [5] stating "education is the main foundation in the development of one's abilities. With education, the potential can be explored and developed." Students are expected to actively memorize rather than understand concepts so that students' thinking ability such as critical thinking becomes less developed [6]. Based on the situation, teachers directly provides an explanation of the materials and concepts as well as examples. Students are less involved in constructing their knowledge to understand the concepts. Critical thinking which includes the ability to analyze, draw conclusions, build interpretations, explanations, self-regulation, curiosity, systematic, seek the truth, and confidence in thinking process are required by individual to solve problems [7]. This opinion is affirmed by [8] stating "critical thinking skill is the ability of logical and reflective thinking focused on making trusted decisions ". Concerning critical

thinking skills in Pontianak Islamic Public High School, it is shown that 0 student or 0% is in the "very high" category, 2 students or 6.25% are in the "high" category, 23 students or 71.86% are in the "medium" category, 5 students or 15.63% are in the "low" category and 2 students or 6.25% are in the "very low" category [9]. In addition, from research conducted by [10] by providing tests of mathematical critical thinking skills conducted by researchers at SMP Ar-Rahman Percut, 2 out of 30 students can answer questions correctly and completely, while others only guess. Based on these findings, it can be concluded that the mathematical critical thinking skills of students in SMP of Ar-Rahman Percut are still low. The conclusion drawn from this study is that students do not possess a high critical thinking ability in solving mathematics questions. Students require knowledge they have to make decisions to complete the questions. Decision making requires anticipation so it obtains better ways of thinking knowledge as well as ways of finding different knowledge of every individual. To obtain knowledge of each individual is usually influenced by habits or the environment. The knowledge or cognitive in the learning of each student can explain differences in student success. Critical thinking skills possessed by students will be very advantageous for the future as they with critical thinking skills can decide and solve the problems they will encounter [11].

From these results, it is essential to conduct learning that involves active and creative students that is through Problem Based Learning approach. According to [12] "Problem Based Learning Model is a learning model involving authentic problems in students learning approach so they can manage their knowledge". PBL approach is a learning approach based on problems, in which teachers relate problems in students' real-life with mathematics learning, so they will obtain the benefits of learning mathematics and gain novel knowledge that is more tangible [13]. According to [14] "problem-based learning is a learning approach that states problems as a starting point to begin the learning and is designed as learning that requires students to gain the ability to solve problems, independence and take participation in order to gain new knowledge". The learning process requires materials in

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accordance with students' knowledge capacity and teachers can provide assistance or intervention in instructions (scaffolding) that direct students to find solutions. The action taken by teachers that is considered can improve students' critical thinking skills and self-confidence is the use of HOTS questions in mathematics learning. The concept of Higher Order Thinking Skills (HOTS) teaches students to process the ability creatively, analytically or synthetically. Thus, the concept of HOTS will change students' thinking ability that is initially passive to become active in processing information. The HOTS concept will result in students' critical thinking skills through evaluations by the teachers [15]. According to [16] "activity undertaken by teachers to determine the students' ability of higher order thinking (HOT) is known as measurement since every activity in this world is inseparable from the measurement." The success of administering the test to students, such as conducting tests containing HOTS questions, can be found from the measurement. The results of measurements by the teacher are trusted if the results of several tests on the same subject generate relatively similar results (reliable). Reasoning ability is a higher order thinking skill that students must possess and develop. Thus, learning must be able to train students' higher-order thinking skills to foster good reasoning power [17]. According to [18], it is important to train children to think at a high level, namely understanding information, quality thinking, and achieving quality outcomes to become independent. The better the students' thinking skills, the better the impact on student learning outcomes will be. Therefore, the use of HOTS questions on learning affects students' interest in learning. Based on the problems, the researchers collaborate on the problem-based learning approach with the assistance of HOTS questions which aim to increase students' critical thinking and self-confidence. The HOTS questions used are expected to bring critical thinking to students, so the learning experienced by students is more enjoyable, active and interesting. Based on the description above, the researchers are interested in conducting research with entitled "Analysis of Student's Critical Thinking Skills Through Problem-Based Learning Approach Using Hots Questions in SMA N 13 Medan".

2. RESEARCH METHOD

Based on the focus of the problems, the research used a qualitative approach. Qualitative research means this research aims to describe the ability to think critically through a problem-based learning approach using HOTS questions. The data are generated in verbal form or utterances obtained from interviews and writing or numbers obtained from interviews. Based on the qualitative approach in this study, all written and spoken facts from participants as data sources and other related documents are described as they are and then reviewed as concisely as possible to answer the problem. This research was conducted at SMA N 13 Medan during odd semester 2019/2020, the schedules were coordinated with school activities and held in July-December 2019. The subjects were students of SMA Negeri 13 Medan Class X MIA2 consisting of 20 students. The results of critical thinking skills are obtained through administering written tests after the

Problem-Based Learning (PBL) approach implementation to the subjects in the material of linear systems of three variables. Tests were handed out to all students who had learned using Problem Based Learning (PBL) approach. This test is used to measure the critical thinking skills of students in class X MIA2 SMA. The type of test refers to the determined competency with benchmark assessment. Items used on this test instrument as the measurement are 4 items in the essay form as follows:

TABLE 1.

CONPLTENT OUTLINE OF CRITICAL THINKING SKILLS TEST

Aspects of Critical Thinking Skills	Measured Indicators	Number of Items
Interpretation	Understanding problems by writing what is found and asked related to the questions.	1,2,3,4,5
Analysis	Identifying the relationship between statements, questions, and concepts given in questions which are shown by building a correct mathematical model and providing the right answers.	1,2,3,4,5
Evaluation	Using the precise strategy to solve the problems, complete and correct in the calculation.	1,2,3,4,5
Inference	Drawing a conclusion from the questions precisely.	1,2,3,4,5

The distinguishing power of the question is the ability of the question to distinguish between high-ability students and low-ability students. The distinguishing power of essay questions is described in the following formula:

$$DP = \frac{\bar{X}_A - \bar{X}_B}{SMI} \dots\dots\dots[19]$$

Information:

- DP : Index of item distinguishing power
- \bar{X}_A : The mean score of top group
- \bar{X}_B : The mean score of lower group
- SM I : Ideal maximum score

The classification for distinguishing power is divided into the following interpretations according to Arikunto (in Banjarnahor, 2017: 96) in Table 2. below.

TABLE 2.

INTERPRETATION OF DISTINGUISHING POWER

Distinguishing Power Coefficients	Interpretation
0,70 < D ≤ 1,00	Very Good
0,40 < D ≤ 0,70	Good
0,20 < D ≤ 0,40	Enough
0,00 < D ≤ 0,20	Poor
D < 0,00	Very Poor

At this stage, an analysis is conducted to the extent to which improvements occur in students' mathematical critical thinking skills. The analysis process is descriptive. Prior to analyzing the improvement, minimum and maximum score must be

obtained from all students by grouping the smallest data to the highest data.

minimum = the lowest score of students

maximum = the highest score of students

The analysis of improvement is performed by finding the mean score obtained from all students using the following formula:

$$Mean(\bar{x}) = \frac{Total\ Data}{Number\ of\ Data}$$

Next, the standard deviation and variance values of the average values are found to see the data distribution to what extent it is close to the mean using the formula:

$$s = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}$$

Where:

S = standard deviation

x_i = x value of i-th

\bar{x} = mean

n = number of samples

$$s^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}$$

Where:

s^2 = variance

x_i = x value of i-th

(\bar{x}) = mean

n = number of samples

From the standard deviation values obtained, then proceed by connecting students' scores to the specified scoring interval in the following:

TABLE 3.

SCORING INTERVALS OF STUDENTS' CRITICAL THINKING SKILLS TESTS IN MATHEMATICS

Scoring Interval	Scoring Criteria
$0 \leq SKBKM < 50$	Low
$50 \leq SKBKM < 80$	Medium
$80 \leq SKBKM \leq 100$	High

Note: SKBKM = Score of Critical Thinking Skills in Mathematics

The score of each participant is determined based on the results of the test. Students' answer sheets are based on the guidelines for scoring critical thinking skills, then the score from each student is categorized based on the scoring categories found in the school. Analysis of students' critical thinking skills in mathematics has achievement indicator of critical thinking. The following table presents achievement indicators for each level of thinking.

TABLE 4.

INDICATORS OF ACHIEVING CRITICAL THINKING SKILLS

Critical Thinking Indicator	Characteristics	Indicator
0 Interpretation	Students understand the problem by writing what is found and asked related to the questions correctly.	1. Formulate main problems
1 Analysis	Students identify the relationship between statements, questions, and concepts given in questions which are shown by building a correct mathematical model and providing the right answers.	1. Disclose facts required to solve problems 2. Choose a logical, relevant and accurate argument
2 Evaluation	Students use the precise strategy to solve the problems, complete and correct in the calculation.	1. Choose a logical, relevant and accurate argument 2. Detect bias based on a different perspective
3 Inference	Students draw conclusion from the questions precisely.	1. Detect bias based on different perspective 2. Determine questions to make a decision

3. RESULTS AND DISCUSSION

The purpose of this study is to describe the quality of students' critical thinking skills and self-confidence through Problem-Based Learning approach using HOTS (Higher Order Thinking Skills) questions in SMA Negeri 13 Medan. After the implementation of Problem-Based Learning Approach (PBL) on the material of linear systems of three variables for 3 (three) meetings, it continued with tests to find students' critical thinking skills in mathematics. Students' answer sheets were checked based on students' critical thinking scoring guidelines. The following are the results of the descriptive statistics containing the characteristics of the sample in sample size, minimum value, maximum value, mean, and standard deviation. The results of the calculation of students' critical thinking skills in mathematics are shown in Appendix D.1, while the summary results are presented in Table 5. below.

TABLE 5.

DESCRIPTION OF STUDENTS' CRITICAL THINKING SKILLS IN MATHEMATICS

Critical Thinking Skills Indicator	N	x_{min}	x_{max}	\bar{x}	SD
Complete Critical Thinking Skills	20	44	87	71	13,95
Interpretation	20	5	11	8.7	1.92
Analysis	20	5	15	11.5	3.44
Evaluation	20	6	14	11.6	3.17
Inference	20	5	10	7.6	1.54

Furthermore, based on Table 4.1, the mean of 20 students to complete critical thinking skills in mathematics is 71. The range value of 44-87 means that students have low critical thinking skills in mathematics with a minimum value of 44 with 2 students and student with high critical thinking skills has a maximum value of 87 with 1 student whose range is 43. The standard deviation value is 13.95 and the mean of 71 imply that the data are less varied due to standard deviation is smaller than mean. Based on the mean score of students' critical thinking skills in mathematics in the table above, the level of students' critical thinking skills in mathematics is described in Table 6. below:

TABLE 6.
DESCRIPTION OF STUDENTS' CRITICAL THINKING SKILLS IN MATHEMATICS

Score Interval	Number of Students	Percentage	Scoring Criteria	The Mean of Critical Thinking Skills
$0 \leq SKBKM < 50$	5 Students	10%	Low	71
$50 \leq SKBKM < 80$	11 Students	20%	Medium	
$80 \leq SKBKM \leq 100$	4 Students	7%	High	

Note: SKBKM = Score of Critical Thinking Skills in Mathematics

A more detail description is presented in Figure 1. the level of students' critical thinking skills in mathematics after the implementation of Problem-Based Learning approach.

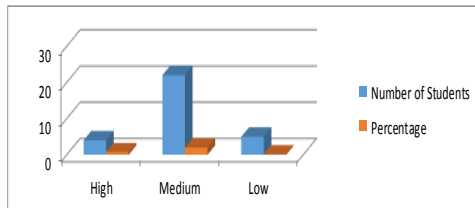


Figure 1 Diagram of Students' Critical Thinking Skills in Mathematics

From the results of the data calculation, it shows that the mean of critical thinking skills is 71 which is in the 50-80 interval and the students' critical thinking skills in mathematical are in the medium category. Besides, the high critical thinking skills category consists of 4 students out of a total of 20 students (7%), the "medium" category is 11 students (20%), and the "low" category is 5 students (10%). Based on Figure 4.1, it presents that the level of students' critical thinking skills in mathematics after the implementation of problem-based learning approach is conducted mostly in "low" category. Based on the results of the critical thinking skills test, it describes the level of students' critical thinking skills in mathematics on each indicator as follows:

4.1.1.1 Interpretation Indicator (Indicator I)

Interpretation ability has an average of 8.7 with a value range of 5-11, it means that the level of students' critical thinking skills in mathematics is low with a minimum value of 5 from 2

students and high critical thinking skills peaks in a maximum of 11 taken from 2 students with a range of 6. The standard deviation is 1.92 and the mean is 8.7. This implies that the data are less varied because the standard deviation is smaller than mean as presented in Table 4.1 page 103.

The results of the interpretation ability indicators obtain the results of as shown in Table 6. below:

TABLE 6.
DESCRIPTION OF INTERPRETATION ABILITY

Score Interval	Number of Students	Percentage	Scoring Criteria	The Mean of Critical Thinking Skills
$0 \leq SKBKM < 4$	-	-	Low	8,7
$5 \leq SKBKM < 9$	9 Students	16%	Medium	
$10 \leq SKBKM \leq 14$	11 Students	20%	High	

Note: SKBKM = Score of Critical Thinking Skills in Mathematics

To see more details, this is presented in Figure 2. The level of students' critical thinking skills in mathematics after the implementation of Problem Based Learning approach.

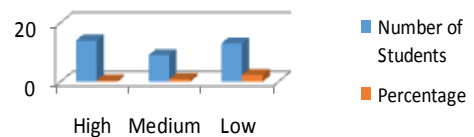


Figure 2. Diagram of Interpretation Ability of Students' Critical Thinking Skills in Mathematics

From the analysis, it is found that the mean of interpretation ability is 8.7 or is interval of 5-9, which means that the interpretation ability is "medium" category, there are 11 students out of 20 students (20%) included in "high" category, 9 students (16%) are "medium" ability category. Based on Figure 4.2, hence, the level of students' critical thinking skills in mathematics after the implementation of problem-based learning approach is conducted mostly in "high" category, this shows that students can understand the problems indicated by writing what is found and asked precisely.

4.1.1.2 Analysis Indicator (Indicator II)

The ability of analysis has an average of 11.5 with a value range of 5-15 means that the level of students' critical thinking skills in mathematics is low at a minimum value of 5 with total 2 students and high level of students' critical thinking skills in mathematics is a maximum value of 15 from 5 students with range of 10. The standard deviation of 3.44 and the mean of 11.5 show that the data are less variable because the standard deviation is smaller than mean as shown in Table 7. page 103. The test results of the analysis indicators administered to students obtain the results in Table 7.

TABLE 7.

DESCRIPTION OF ANALYSIS ABILITY

Score Interval	Number of Students	Percentage	Scoring Criteria	The Mean of Critical Thinking Skills
$0 \leq \text{SKBKM} < 5$	2 Students	4%	Low	11,5
$6 \leq \text{SKBKM} < 10$	5 Students	9%	Medium	
$11 \leq \text{SKBKM} \leq 15$	13 Students	23%	High	

Note: SKBKM = Score of Critical Thinking Skills in Mathematics

The details are presented in Figure 3. The level of students' critical thinking skills in mathematics after the implementation of Problem-Based Learning approach.

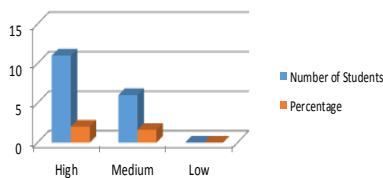


Figure 3. Diagram Analysis Ability of Students' Critical Thinking Skills in Mathematics

From the analysis results it is found that the mean of analysis skills is 11.5 with the interval of 11-15, which means the analysis ability is in "high" category, 2 out of 20 students (14%) have a "low" category, 5 students (9%) are included in "medium" category, and 13 students (23%) are "high" category. Based on Figure 4.3, it concludes that the level of students' critical thinking skills in mathematics after the implementation of problem-based learning approach is conducted mostly in "high" category. This shows that students identify the relationships between statements, questions, and concepts given in the questions by building mathematical models correctly and giving the right explanation.

4.1.1.3 Evaluation Indicator (Indicator III)

Evaluation ability has a mean of 11.6 with a value range of 6-14, it means that the level of students' critical thinking skill in mathematics is low with a minimum value of 6 from 2 students and high critical thinking skills in mathematics has a maximum value of 14 from 10 students within the range of 8. The standard deviation of 3.17 and the mean of 11.6 show that the data are less variable because the standard deviation is smaller than mean as shown in Table 8. page 103. The results of the evaluation ability indicators given to students obtain the results in the following Table 8.

Table 8.

The Evaluation Ability Indicators

Score Interval	Number of Students	Percentage	Scoring Criteria	The Mean of Critical Thinking Skills
$0 \leq \text{SKBKM} < 5$	-	-	Low	11,6
$6 \leq \text{SKBKM} < 10$	6 Students	11%	Medium	
$11 \leq \text{SKBKM} \leq 15$	14 Students	27%	High	

Note: SKBKM = Score of Critical Thinking Skills in Mathematics

For more details, it is presented in Figure 4.4. The level of students' critical thinking skills in mathematics after the implementation of Problem Based Learning approach.

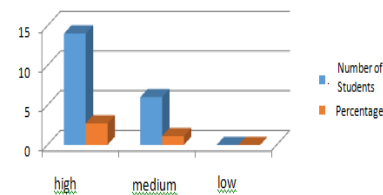


Figure 4. Diagram of Evaluation Ability of Students' Critical Thinking Skills in Mathematics

From the analysis, it is found that the mean of the evaluation ability is 11.6 or interval of 11-15, which implies that the evaluation ability is "high" category, 6 students out of 20 students (11%) with "medium" category, 14 students (27%) are "high" category. Based on Figure 4.4, hence, the level of students' critical thinking skills in mathematics after the implementation of problem-based learning approach is conducted mostly in "high" category, this shows that students can utilize the precise strategy in solving problems, complete, and correct in calculations.

4.1.1.4 Inference Indicator (Indicator IV)

Inference ability has an average of 7.6 and range value of 5-10, which implies that the level of students' critical thinking skills in mathematics is low with a minimum value of 5 from 3 students and the high level of students' critical thinking skills in mathematics has maximum of 10 from 2 students with range of 5. The standard deviation of 7.6 and the mean of 1.54 shows that the data are less varied because the standard deviation is smaller than mean as presented in Table 9. page 103. Results of evaluation ability indicator given to students obtain the results of table 9:

Table 9.
Inference Indicators

Score Interval	Number of Students	Percentage	Scoring Criteria	The Mean of Critical Thinking Skills
$0 \leq \text{SKBKM} < 5$	3 Students	6%	Low	7,6
$6 \leq \text{SKBKM} < 10$	17 Students	36%	Medium	
$11 \leq \text{SKBKM} \leq 15$	-	-	High	

Note: SKBKM = Score of Critical Thinking Skills in Mathematics

For more details, it is shown in Figure 4.5. The level of students' critical thinking skills in mathematics after the implementation of Problem Based Learning approach.

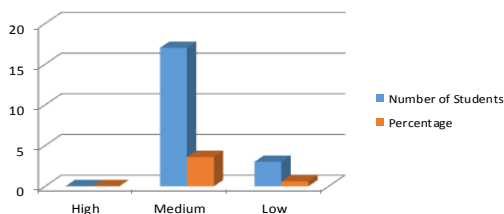


Figure 5. Level of Inference Ability of Students' Critical Thinking Skills Test

From the results of analysis, it is found that the mean of inference ability is 7.6 with interval of 6-10, which means that the inference ability is "medium" category, 3 students out of 20 students (6%) have "low" category, 17 students (36%) are in "medium" category. Based on Figure 4.5, therefore, the level of students' critical thinking skills in mathematics after the implementation of critical thinking skills is conducted mostly in the scoring category while this shows students can draw conclusions from what is asked appropriately.

DISCUSSION

In the previous mathematics learning process, mathematics learning has been centered on teachers while students are the objects. Students do not have enough time to construct the knowledge, concepts, and principles they have in learning mathematics. [21] Learning is a complicated process because it does not merely absorb information from the teacher, but also involves various activities and actions that must be taken to achieve good learning outcomes. Whereas [22], in learning theory state that "students' thinking skills have the responsibility in solving problems so they become independent". Vygotsky believes that social interaction with others spurs the construction of ideas and enhances children's intellectual development. According to [23] "Constructivist principles provide a set of guiding principles to help designers and teachers create learner-centered, collaborative environments that support reflective and experiential processes" which means constructivist principles provide a set of guidelines to help teachers to create a centralized and collaborative learning environment that support the reflective process and learning experience. In the learning process conducted for three meetings in class X MIA2 Medan shows

that students activeness is better after applying the Problem Based Learning approach compared to previous learning which utilizes conventional learning, which is lecturing or explaining the theory only. Learning also emphasizes the student-centered learning approach and requires the ability to think critically and mathematically so students can be trained, accustomed, instilled through the interaction between students and teachers. Out of 20 students, 10% or 5 students are "low" ability category, 20% or 11 students are included in "medium" category, and 7% or 4 students are "high" ability category. In line with research by [24] asserting that the level of critical thinking skills of 32 students, the "low" category is 31.2%, "medium" is 53.2%, and "high" is 15.6%. On the indicators of students' mathematical critical thinking skills, namely (1) the interpretation indicator of the "high" category is 20%, which means that 11 students are able to understand the problem well, (2) the analysis indicator for the "medium" category is 9%, which implies that 5 students are able to analyze the problem appropriately, (3) evaluation indicator for "medium" category is 11%, which means that 6 students are able to evaluate the questions correctly, (4) inference indicator for "medium" category is 36%, which shows that 17 students are able to draw conclusions correctly. This is in line with Wahyu Arini, Fikri Juliadi (2018: 10) that "students' critical thinking skills are in "low" category with an average percentage of critical thinking achievement of 35.91%, the percentage of each indicator is 71.19% for interpretation indicator, 25.53% for analysis indicator, 27.14% for evaluation indicator, 32.86% for inference indicator, 36.67% for indicator of explication, and 32.38% in the self-regulation indicator". The level of students' critical thinking skills is dominated by students of medium ability. In addition, only 5 students are included in "low" category of critical thinking skills and 11 students have medium level of critical thinking skills. In addition, the results of students' answers related to the critical thinking tests are not satisfactory as a whole. This happens due to a lack of accustomed to answering questions related to critical thinking.

4. CONCLUSION

Based on the results of the analysis and discussion and findings regarding learning using Problem Based Learning approach, several conclusions are obtained which are the answers to the questions raised in the problem statement. From a total of 20 students, "low" critical thinking skills of 10% are 5 students, "medium" category of 20% has a total of 11 students, and "high" category of 7% totals 4 students.

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