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The Level of Students' Critical Thinking Skills and Mathematical Reasoning

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ABSTRACT

The purpose of this topic is to determine students' critical thinking skills and mathematical reasoning on the absolute value topic. This type of research is quantitative study with quantitative descriptive design. Participants of the research are grade X students in three different schools in the Surakarta. The total number of the participants are 83. The data collection technique was carried out by using a test consisting of 4 question items. The Result study shows that students who had low critical thinking skills were 86%, students who had medium critical thinking skills were 12%, and students who had high critical thinking skills were 2%. Whereas for students who have low mathematical reasoning as much as 60%, students who have medium mathematical reasoning abilities are 29%, and students who have high mathematical reasoning abilities are 11%. These results indicate that there are still many students who have low critical thinking skills and there are still many students who have low mathematical reasoning abilities.

Keywords: Critical thinking, mathematical, skills, systematically

INTRODUCTION

Body In the 21st century, students must have a high-level thinking skill [1]. Cheng [2] stated that 21st century skills and literacy include basic skills, technology skills, problem solving skills, communication skills, critical and creative thinking skills, information or digital skills, inquiry or reasoning skills, interpersonal skills, and multicultural and multilingual skills. Therefore critical thinking skills and reasoning abilities are important for students to have. In this case, the efforts made by the government are contained in the 2006 Ministry of Education Regulation. The Minister of National Education Regulation (Permendiknas, 2006) that the competency standards that apply in mathematics learning at the secondary school level must improve students' logical, analytical, systematic, critical, creative, and cooperative abilities[3]. Besides, the Minister of National Education Regulation No. 22 of 2006 concerning Content Standards for Elementary and Secondary Education Units stipulates that one of the goals of mathematics is to enable students to push themselves to achieve reasoning abilities in terms of patterns and qualities, carry out mathematical manipulations in generalizing, gathering evidence, or explaining ideas and statements mathematics [4].

Some experts put forward the definition of critical thinking including namely Ennis in Baron and Stenberg (1987) stated that critical thinking is defined as reflective thinkingwhich is grounded and focused on the determination of what is believed or done[5]. According to Hassoubah [6],critical thinking is the ability to give reasons in an organized manner and evaluate the quality of a reason systematically. Whereas Glazer [7] explained that critical thinking is ability and disposition to involve prior knowledge, mathematical reasoning, and cognitive strategy to generalize, prove or evaluate unfamiliar mathematical situation reflectively.

Marzano said [8], components of critical thinking skills are analyzing, making comments, self-regulation, assumption identification, explanation, and evaluation. Sumarmo [9] revealed that indicators of mathematical critical thinking ability consisted of 1) focusing on one question, problem, and theme. 2) check the truth of arguments, statements and solution processes. 3) ask and answer accompanied by reasons. 4) observe with criteria, identify assumptions, understand well, and identify relevant and irrelevant data. 5) reduce and induce. 6) make judgments, assess thoroughly. 7) find alternatives. Whereas Ennis [10] revealed 12 indicators of critical thinking skills divided into the following five major groups, 1) providing simple explanations such as focusing questions, analyzing arguments, asking and answering about an explanation or challenge, 2) building basic skills such as considering the credibility

of the source, observing and considering an observation report, 3) concluding such, deducting and considering the results of the deduction, inducing and considering the results of induction, making and determining the value of consideration, 4) providing further explanations such as, defining terms and considering definitions, 5) identify assumptions. Manage strategies and tactics such as, determine actions, interact with others.

[11]The mathematical reasoning is the skill of learners to give reasons and prove the outcome of their thinking using time and manner or procedure appropriately. Mathematical reasoning is a basic of mathematics in understanding the concepts, ideas and procedures to draw a conclusion [12]. Ario stated that in general mathematical reasoning can be classified into two types, namely inductive reasoning and deductive reasoning. Inductive reasoning is reasoning based on a limited number of cases or examples that are observed. Deductive reasoning is the process of reasoning from knowledge of principles or general experience that leads us to conclusions for a particular [13]. Sumarmo and Hendriana [14] further explained inductive reasoning including analogy reasoning, generalization, estimation or estimation of answers and solution processes, and constructing conjectures. Inductive reasoning above can be classified as thinking mathematically low or high level depending on the complexity of the situation involved. While deductive reasoning includes performing arithmetic operations; draw logical conclusions; explain the model, facts, nature, relationships or patterns; propose opposing examples; follow the rules of inference; check the validity of arguments; construct valid arguments; formulate a definition; and construct direct proof, indirect proof, and proof by mathematical induction.

Based on the description above, the researcher will investigate the level of critical thinking skills of students with indicators: analyze and explain questions, answers, or arguments, make deductions; and students' mathematical reasoning abilities with indicators: make logical conclusions, estimate answers and process solutions, proof, and carry out calculations based on certain rules or formulas.

RESEARCH METHOD

The research method used is quantitative study with quantitative descriptive design. The quanitative descriptive research methods have become the common procedures in conducting the research in many disciplines, including education[15]. The participants of the study are grade X students in three different schools in the Surakarta. The total number of the participants are 83.

In this study, there are 3 stages, namely: (1) Preparation stage, wherein this preparation stage makes and studies problems contained in the field, makes the background of theoretical studies, arranges instruments, prepares instruments, manages licenses to the principal by asking permission to the School Representative in the Curriculum field, then discuss with the mathematics subject teacher to determine the schedule and class to be examined. (2) The next stage is the implementation phase, where at this stage provides tests in the form of instruments about critical thinking skills and mathematical reasoning to students in the form of 4 item description questions that have been consulted with the supervisor. (3) The next step is to analyze the data obtained from the provision of critical thinking skills tests and mathematical reasoning of grade X students on the absolute value topic. The results of student work are then given a score by referring to the grading rubric that has been modified as in Table 1.

Table 1. Scoring Rubric of Students' Critical Thinking Ability

Indicator	Student responses to questions	Score
Analyze and explain questions, answers, or arguments	Does not answer or answer does not match the problem	0
	Expressing most of the questions, answers or arguments correctly.	1
	Expressing a part of the question, answer or argument correctly.	2
	Expressing almost all questions, answers or arguments correctly.	3
	Express all the questions, answers or arguments correctly and completely	4
Do deductions	Does not answer or answer does not match the problem.	0
	Do almost the right deduction	1
	Do a partial deduction correctly	2
	Do almost complete deduction correctly.	

Perform deductions correctly and completely	4

Grouping criteria for students' critical thinking skills according to Arikunto [16] as in Table 2 below.

Table 2. Criteria for Critical Thinking Ability

Score	Criteria
$\mathbf{80\% - 100\%}$	Very high
$\mathbf{66\% - 79\%}$	High
$\mathbf{56\% - 65\%}$	Medium
$\leq \mathbf{55\%}$	Low

As for the assessment of mathematical reasoning ability based on the following Table 3.

Table 3. Scoring Rubrics on Students' Mathematical Reasoning Capabilities

Indicator	Student responses to questions	Score
Make logical conclusions	Does not answer or answer does not match the problem	0
	Conclude from false statements	1
	Conclude from statements but there are some errors	2
	Conclude from statements but there are few errors	3
	Draw conclusions from statements	4
Estimating the answer and the solution process.	Not answering or answering is not following the problem	0
	Proposing the answer is almost partially correct	1
	Propose a possible answer partially correct	2
	Propose possible answers with almost all of them correct	3
	Submitting possible correct and complete answers	4
Proof	Does not answer or answer does not match the problem	0
	Carry out proof that is almost partly true	1
	Carry out partial proof correctly	2
	Carry out proof that is almost entirely correct	3
	Proving correctly and completely	4
Carry out calculations based on certain rules or formulas	Does not answer or answer does not match the problem	0
	Finding the relationship between facts, concepts, principles of certain rules in solving problems is almost partly true	1
	Finding the relationship between facts, concepts, principles of certain rules in problem-solving with partially correct	2
	Finding the relationship between facts, concepts, principles of certain rules in solving problems is almost entirely correct	3
	Finding the relationship between facts, concepts, principles of certain rules in solving problems correctly and completely.	4

Furthermore, to find out the category of student scores can be seen in the following Table 4.

Table 4. Categories of Results in Students' Mathematical Reasoning Assessment Capabilities [17]

Category	Achievement of Mathematical Reasoning Capabilities
High	$> 70\%$
Medium	$55\% \geq 70\%$
Low	$< 55\%$

RESULTS AND DISCUSSION

Students data regarding critical thinking skills and mathematical reasoning abilities of students are then processed to determine the level of student ability. The results of student data processing on critical thinking skills are presented in Table 5 below.

Table 5. Level of students' critical thinking skills

Category	Total Students	Percentage
High	2	2%
Medium	10	12%
Low	71	86%

Next is shown the percentage of the number of students in each score on each indicator as in Table 6 below.

Table 6. Percentage of Number of Students in Each Score on the Critical Thinking Indicator

Indicator	No. Question	Score 1		Score 2		Score 3		Score 4	
		N	%	N	%	N	%	N	%
Analyze and explain questions, answers, or arguments	1	57	68,67	16	19,28	6	7,23	1	1,20
Do deductions	2	19	22,89	31	37,35	20	24,10	3	3,61

Based on the data in table 6 above, it can be seen that from the research subjects were 83 students, the number of students on the indicator analyzed and explained questions, answers or arguments score 1 was 68.67%, score 2 was 19.28%, score 3 was 7, 23%, and a score of 4 as much as 1.20%. From these scores, it can be concluded that the highest number of students is in score 1, thus 68.67% of students can only state most questions, answers or arguments correctly. More details are presented in the form of a pie chart as in Figure 1 below.

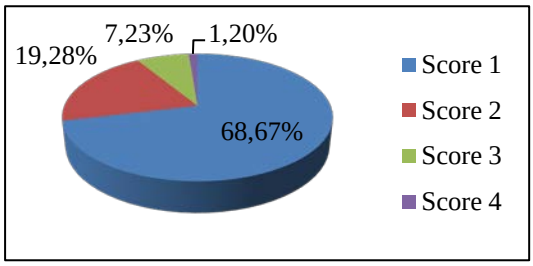

Figure 1. Percentage of Number of Students in Each Score on the Indicator Analyzing and Explaining Questions, Answers, or Arguments

On the indicators of deduction, the number of students on a score of 1 was 22.89%, score of 2 was 37.35%, a score of 3 was 24.10%, and score of 4 was 3.61%. From these scores, it was concluded that the percentage of the number of students who dominated the indicators of deduction was a score of 2, thus 37.35% of students did a partial deduction correctly. More details are presented in the form of a pie chart as in Figure 2 below.

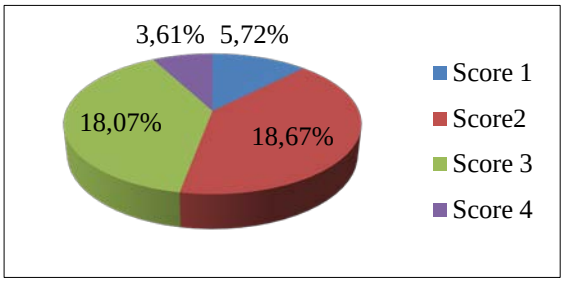

Figure 2. Percentage of Number of Students in Each score on the Indicator Deduction

While the results of student data processing on mathematical reasoning ability are presented in Table 7 below.

Table 7. Students' Mathematical Reasoning Ability Levels

Category	Total Students	Percentage
High	9	11%
Medium	24	29%
Low	50	60%

Next is shown the percentage of the number of students in each score on each indicator as in Table 8 below.

Table 8. Percentage of Number of Students in Each Score on the Mathematical Reasoning Indicator

Indicator	No. Question	Score 1		Score 2		Score 3		Score 4	
		N	%	N	%	N	%	N	%
Make logical conclusions	1a	27	32,53	20	24,10	18	21,69	13	15,66
Estimating the answer and the solution process.	1b	24	28,92	15	18,07	11	13,25	31	44,57
Proof	2a	59	71,08	11	13,25	3	3,61	4	4,82
Carry out calculations based on certain rules or formulas	2b	12	14,46	32	38,55	4	4,82	7	8,43

Based on the data in table 8 above, it can be seen that from the research subjects as many as 83 students, the number of students on the indicators making logical conclusions on a score of 1 was 32.53%, a score of 2 was 24.10%, a score of 3 was 21.69%, and a score of 4 was 15.66%. From these scores, it can be concluded that score 1 is a score that dominates among other scores, thus 32.53% of students conclude false statements. More details are presented in the form of a pie chart as in Figure 3 below.

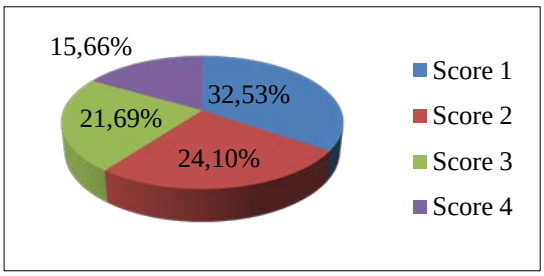

Figure 3. Percentage of the Number of Students in Each Score on the Indicator Making Logical Conclusions

The number of students on the indicator estimates the answer and the solution process obtained a score of 1 was 28.92%, a score of 2 was 18.07%, a score of 3 was 13.25%, and a score of 4 was 44.57%. From these scores, it can be concluded that the score that dominates among other scores is a score of 4, thus 44.57% of students can submit possible answers correctly and completely. More details are presented in the form of a circle diagram as shown in Figure 4 below.

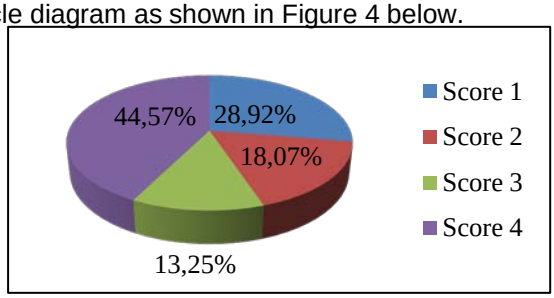

Figure 4. Percentage of Number of Students in Each Score on Indicator Estimating Answers and Solution Process

The number of student scores on the proof indicator obtained a score of 1 was 71.08%, a score of 2 was 13.25%, a score of 3 was 3.61%, and a score of 4 was 4.82%. From these scores, it can be concluded that the score that dominates among other scores is a score of 1, thus as much as 71.08%, students can only do proof with almost partially correct. More details are presented in the form of a pie chart as in Figure 5 below.

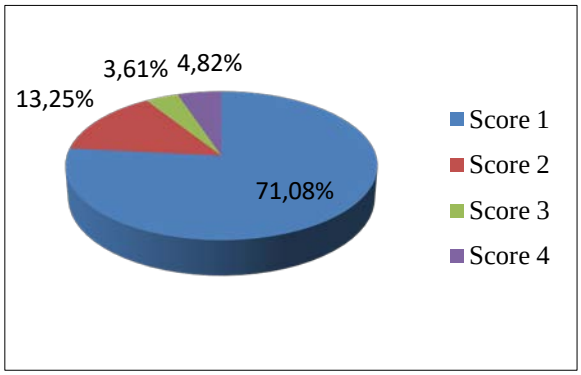

Figure 5. Percentage of Number of Students in Each Score on the Proof Indicator

The number of students in each score on the indicator carrying out calculations based on certain rules or formulas obtained a score of 1 was 14.46%, a score of 2 was 38.55%, a score of 3 was 4.82%, and a score of 4 was 8.43%. From these scores, it can be concluded that the score dominates among other scores is score 2, thus 38.55% of students can find the relationship between facts, concepts, principles of certain rules in solving problems partially correctly. More details are presented in the form of a circle diagram as shown in Figure 6 below.

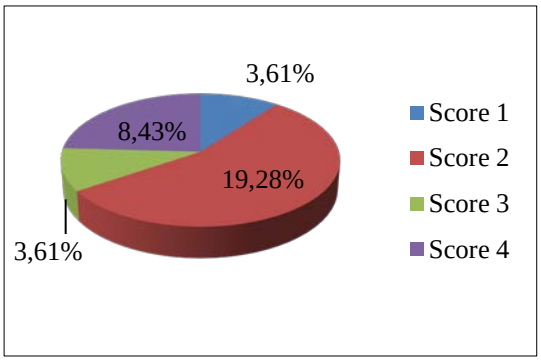

Figure 6. Percentage of Number of Students in Each Score on the Indicator Carry Out Calculations Based on Specific Rules or Formulas

CONCLUSIONS

Based on the description above, it can be concluded that students who have low critical thinking skills are 86%, students who have moderate critical thinking skills are 12%, and students who have high critical thinking abilities are 2%. Furthermore, the percentage of the number of students who dominated in each score on the indicator of critical thinking ability starts from analyzing and explaining questions, answers or arguments is a score of 1 as much as 68.67%, the number of students in each score on the indicator of deduction that dominates is a score of 2 as much as 37, 35%. Whereas for students who have low mathematical reasoning as much as 60%, students who have moderate mathematical reasoning abilities are 29%, and students who have high mathematical reasoning abilities as much as 11%. Furthermore, the percentage of the number of students who dominated in each score on the indicators of mathematical reasoning ability starting from making logical conclusions is a score of 1 as much as 32.53%, the number of students in each score on the indicator giving answers and the solution process that dominates is a score of 4 as much as 44.57%, the number of students in each score on the indicator proves that the dominant one is 71.08%, and the number of students in each score on the indicator to calculate based on certain rules or formulas that dominate is a score of 2 as much as 38.55%.

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