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ANALYZING STUDENT'S MATHEMATICAL CRITICAL THINKING ABILITY OF CONCEPT NEWMAN'S ERROR ANALYSIS REVIEW FROM HABITS OF MIND

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ABSTRACT

This study aims to analyze and describe the mistakes made by students in completing mathematical critical thinking skills in terms of habits of mind (HOM) with three categories, namely limited, developing, and proficient. The review was also analyzed from the factors that led to the occurrence of errors based on error analysis according to Newman. This research uses qualitative research methods. The data collection techniques used are questionnaires, tests, and interviews. The instruments used are HOM questionnaires and mathematical critical thinking ability tests. The selection of the study subject was carried out purposively with the consideration that the subject had a HOM category. A total of 25 students who filled out the HOM scale and mathematical critical thinking ability test, 3 students were selected to be interviewed based on the HOM category classification. The data analysis techniques used in this study are data reduction, data presentation, and drawing conclusions. Based on the results of the study, students with limited HOM were only able to solve questions up to indicator 1 because they made mistakes in reading and process skills. Students with HOM develop, only able to solve problems up to indicator 2 due to Comprehension and transpormation errors. Students with proficient HOM, are able to solve questions up to indicator 3 because they make mistakes in the skill and encoding process.

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INTRODUCTION

Learning mathematics is very close to everyday life, so students are expected to be able to understand mathematics in various contexts and apply it in everyday life. Mathematics is a means of thinking to develop the ability to think logically, systematically and critically (Pulungan & Reflina, 2022). The ability to think critically is so important in 21st century learning, because critical thinking according to Ridwan (2019) is included in the ability to

think at a high level, where the ability is expected by the government to be a means to increase Indonesia's competitiveness in the international arena in the field of education.

The importance of higher order thinking skills is expressed by Collins (2014), namely to prepare students to face increasingly complex problems in the 21st century. This is supported by the vision of mathematics, especially for future needs, namely learning mathematics provides opportunities for the development of logical, systematic, critical, creative and careful reasoning abilities as well as objective and open thinking which are very necessary to face an ever-changing future (Hendriana et al. al., 2014). Critical thinking skills and mathematics are closely related and cannot be separated, because mathematical material is understood through critical thinking, and critical thinking is trained through learning mathematics (Nurdiansyah et al., 2021). Critical thinking skills are also important because it is a process that will lead to conclusions and actions to be taken (Sumarmo et al., 2012; Tresnawati et al., 2017).

The importance of mathematical critical thinking skills is not in line with what happens to students. Looking at the facts from the results of the PISA (Program for International Student Assessment) research in 2018 in the field of mathematics, Indonesia was ranked 73 out of 80 countries with a score of 379 (Tohir, 2019). It was further explained that 75.7% of Indonesian students had low performance and were only able to do simple questions, and only 0.1% of students were able to complete mathematical modeling which required thinking and problem solving skills (Nur & Palobo, 2018). According to Ulva's research (2018) the level of critical thinking skills of Indonesian students is still low, then students' mathematical abilities, especially in understanding, communication, connections, problem solving, reasoning and students' mathematical creative thinking are not optimal (Dilla et al., 2018; Hidayat, 2017; Rohaeti et al., 2019)

Critical thinking ability is an essential and important high-level thinking ability for students in understanding mathematics, where in critical thinking one thinks deeply about everything, asks questions and finds relevant information. Critical thinking ability indicators according to Ennis are (1) Simple explanations with indicators that focus questions, analyze questions, and answer questions (Elementary Clarification). (2) Basic skills for making conclusions with indicators considering sources and considering observations. (3) Drawing conclusions with indicators to make and consider the results of deduction, induction, and determining judgment (inference). (4) Further explanation with indicators identifying terms and definitions (Advanded Clarification). (5) Strategies and techniques with indicators consider reasons and assumptions that are still in doubt, make decisions, and determine actions. (Hendriana et al., 2017)

Critical thinking skills have certain criteria, according to Facione (Narwastu et al., 2022) there are six main critical thinking skills involved in the critical thinking process. These skills are interpretation, analysis, evaluation, inference, explanation and self-regulation.

Students when working on questions that require a complex level of thinking, most students still find it difficult (Mahmudah, 2018). These difficulties resulted in students making mistakes in solving problems. So it is necessary to analyze the mistakes made by students. The results of the analysis can later be used by the teacher as a basis for providing learning. Newman classifies five errors made by students, namely errors in reading questions, errors in understanding questions, transformation errors, processing skills errors and errors in writing final answers (Karnasih, 2015; Lubis et al., 2021).

The reading stage is the stage where students cannot read the key words and symbols in the questions and understand the meaning of each word and term. The Comprehension stage is the stage where students cannot understand the contents of the problem as a whole. Transformation stages are stages where students cannot determine the method of completion.

Process Skill stages are stages where students cannot determine the problem-solving design to get answers. The Encoding stage is the stage where students cannot interpret the results of their work to answer questions on Newman's opinion questions (Ardianzah & Wijayanti, 2020).

The directions in the 2013 curriculum and the independent curriculum are not only cognitive aspects that need to be improved but also affective as well as psychomotor aspects (Lubis et al., 2021). Because affective aspects also affect students when answering questions. Students must have one of the affective abilities, namely habits of mind or thinking habits. Good thinking habits are needed by students (individuals) because thinking habits shape individual preferences to behave intellectually or think smartly when faced with a problem. Habits of mind need to be built from an early age so that it becomes a habit to have in solving a problem. But unfortunately, there are still many individuals or students who have poor thinking habits that become an obstacle in solving a problem in everyday life or when working on math problems. The habit of thinking is still an obstacle for students to solve complex problems (Indriani et al., 2018).

Critical thinking ability is divided into several indicators, in this study only five indicators were taken, namely Based on a literature review, there is still potential for research that focuses on descriptions of students' errors in solving mathematical problems concerning mathematical critical thinking ability in terms of habits of mind.

This study aims to describe errors and factors that cause students to make mistakes in solving mathematical critical thinking skills in terms of habits of mind with Newman's Error analysis. Student mistakes need to be explored based on their thinking habits so that students have an intelligent response to questions or problems whose solutions are not immediately known.

METHOD

In this study, the method used is descriptive qualitative which aims to describe the mistakes made by students when working on mathematical critical thinking skills.

This research will be focused on class IX junior high school students. Research subjects were taken using purposive sampling. Purposive Sampling is a data source sampling technique with certain considerations (Sugiyono, 2016). In this research, the consideration is that the subject has a limited, developing, and proficient category of thinking habits. Students make mistakes when working on tests of mathematical critical thinking skills.

The types of instruments used are tests and non-tests. The test instrument used is a mathematical critical thinking test. While the non-test instruments used are questionnaires and interviews. The instrument questions were validated by two validators, namely the Siliwangi IKIP lecturer and the Mathematics Teacher. The validation results by the validator can be seen in Table 1. as follows:

Table 1. Validation Results

Validator	Validation
Validator I	**Criticism and suggestions** Correct the sentences in the questions so that they are more communicative, using good and correct Indonesian General rating Questions can be used, but need to be revised a little
Validator II	**Criticism and suggestions** Improve word choice in translating questions

	General rating
	Tests can be used with revisions

The questionnaire in this study is intended to obtain information about students' habits of mind which will be analyzed into categories of thinking habits, namely: beginner, limited, developing, proficient and expert. The instrument for classifying students' thinking habits uses a modified thinking habit questionnaire from Hendriana et al. (2017) by paying attention to indicators of habits of mind based on Costa & Kallick. The answer choices are sorted from the most negative to the most positive based on the stages of the habits of mind category. If most students choose the most negative answer, it means that the student has a habit of thinking for beginners, as well as other answer choices. The questionnaire grid can be seen in Table 2 below.

Tabel 2. Questionnaire Grid

Indicator	**Statement**	
	Positive (+)	**Negative (-)**
Enduring or never give up	2, 4	1,3
Listening to the opinions of others with empathy	5	6
Identify problem-solving strategies	7	8
Thinking about thinking /metacognititive	9	10
Think flexibly, confidently	11	12
Try to work carefully and precisely	13	14
Ask and file problems effectively with supporting data	15	16
Applying old knowledge to new situation and analogic	17	18
Think and communicate clearly and thoroughly	20	19
Creating, imagining, and innovating	21	22
Eager to responds	23	24
Dare to take responsibility and take risks	25	26
Humorous	27	28
Thinking interdependent	29	30
Continuous learning	31	32

Data collection techniques used in this study were tests of mathematical critical thinking skills, questionnaires, and interviews. The subject filled out the habits of mind attitude scale which was then analyzed for the category of habits of mind possessed by each student, as well as the mistakes made by the subject in working on the mathematical critical thinking ability test questions and the factors that caused these errors.

The stages of data analysis are reduction, presentation, and conclusion. Data reduction means summarizing, choosing the main things, focusing on the important things and looking for patterns (Sugiyono, 2016). After being reduced, the presentation of data in qualitative research can be done in the form of brief descriptions, charts, relationships, flowcharts. Conclusions are drawn by analyzing test results and interviews with students. The conclusion of this study is the result of an analysis of students' errors in solving mathematical critical thinking skills and also the causes of these errors.

RESULTS AND DISCUSSION

Results

This research was conducted on students at one of the junior high schools in Cimahi City, by assigning class IX as the class for taking the research subject. Research conducted in the field included distributing HoM attitude scale questionnaires and filling in mathematical critical

thinking skills test questions. Questionnaires were distributed to 30 class IX students who were present at that time.

The distribution of the questionnaire was carried out with the aim of knowing how students tend to be from the student's HoM indicator. From the questionnaire data obtained the HoM category of each student. Furthermore, after filling in the HoM attitude scale to students, the researcher conducted a critical thinking test on mathematical statistical material that had been studied in class VIII and interviews.

Research that has been conducted discusses how students' errors in completing critical thinking skills are reviewed from the category of habits of mind. Of the 5 categories mentioned by Costa and Kallick, this discussion will only discuss 3 categories in the field, namely the limited category, the developing category, and the advanced category. Errors made by students on the mathematical critical thinking ability test were analyzed by taking into account mathematical critical thinking ability indicators at each scoring level. Researchers also revealed the causes of errors based on Newman's theory which includes 5 types of errors, namely: reading, understanding, transformation, process skills, and final writing.

Table 3. Categories Habits of Mind

HoM Categories	Percentage
Limited	$X \leq \bar{X} - SD$
Developing	$X \geq \bar{X} + SD \geq X \geq \bar{X} - SD$
Advanced	$X \geq \bar{X} + SD$

So that the research data obtained in Table 4 as follows:

Table 4. Results of Student Habits of Mind

Student Code	Score	Percentage	Category
S-1	88	73%	Limited
S-2	82	68%	Limited
S-3	89	74%	Limited
S-4	83	69%	Limited
S-5	90	75%	Developing
S-6	90	75%	Developing
S-7	77	64%	Limited
S-8	84	70%	Limited
S-9	75	63%	Limited
S-10	85	71%	Limited
S-11	71	59%	Limited
S-12	73	61%	Limited
S-13	85	71%	Limited
S-14	94	78%	Developing
S-15	77	64%	Limited
S-16	70	58%	Limited
S-17	85	71%	Limited
S-18	77	64%	Limited
S-19	90	75%	Developing
S-20	92	77%	Developing

Student Code	Score	Percentage	Category
S-21	68	57%	Limited
S-22	118	98%	Advanced
S-23	107	89%	Developing
S-24	86	72%	Limited
S-25	85	71%	Limited
S-26	80	67%	Limited
S-27	92	77%	Developing
S-28	82	68%	Limited
S-29	101	84%	Developing
S-30	89	74%	Limited

Information: The Ideal score of the HoM scale is 120

HoM Limited category

Subjects with habits of mind in the limited category are S1. From the results of the mathematical critical thinking ability test in Figure 1, In question number 2, S1 made an error which was a question with indicators stating arguments at a moderate level of questions, S1 had difficulty reviewing errors according to Newman, an error occurred at the skill process stage because students can not determine the problem-solving design to get answers. In this indicator students do not give their arguments in determining the completion steps. This means that students also make mistakes in reading and understanding the information.

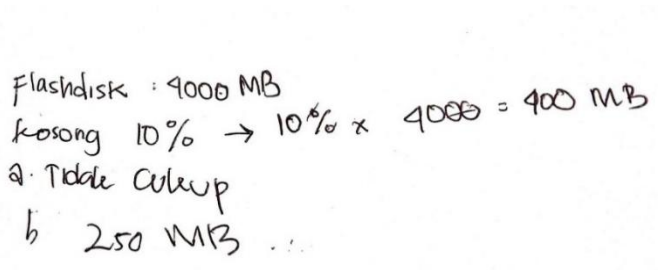

Figure 1. Answare S1

When working on questions, S1 showed several indicators of habits of mind, including lack of confidence which was seen when S1 hesitated in answering and did not try to do it carefully and precisely as seen in question number 1, and indicators of never giving up were minimal because when doing giving explanations on questions and having difficulty S1 tends to guess the answers. Students do not think and communicate clearly and precisely and in metacognitive thinking they are not used to it.

HoM Develop category

Furthermore, S2 is a subject with a growing category of habits of mind. Based on the results of work and interviews with S2, S2 was able to work on the questions correctly according to indicator 1. S2 was also able to work on indicator 2 questions. In question number 3 (figure 2), S2 made a mistake on the indicator to make deductions. However, students cannot meet the indicators of interpreting and using representations based on existing information sources and determining actions accompanied by direct statements of reasons and communicating the results of their interpretations and reasons. Errors occur at the stages of Comprehension and Transformation because students are not able to fully understand everything that is asked and are unable to solve problems, students tend to guess, even students forget formulas.

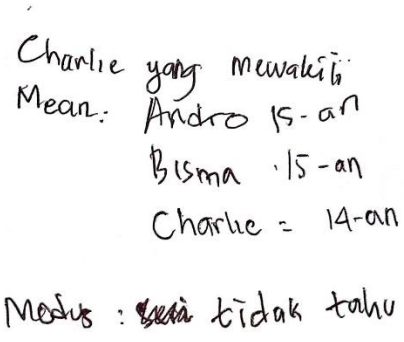

Figure 2. Answers to S2

When working on the questions, S2 showed several indicators of habits of mind, including lack of confidence which was seen when S2 gave up on answering and was not careful enough, only guessing answers without using a basis such as when students were looking for the mean, so the student's answers were wrong. forgot about mode. Students cannot apply previous knowledge to existing problems, are not enthusiastic in responding.

Based on the results of the tests and interviews, it can be seen that the factors that caused S2 to make mistakes were inaccurate and wrong in concluding. According to Newman, there were errors at the Comprehension and Transformation stages.

HoM category Advanced

S3 is a subject with an advanced category in habits of mind. On question number 1 based on work results and interviews with S3, S3 was able to do the questions correctly according to the indicators and was able to give the right reasons. Overall S3 can fulfill all the indicators in indicator questions 1, 2, and 3. However, S2 has difficulties when doing the average search which makes S2 wrong in concluding.

In problem number 4 (Figure 3), S3 made an error on the indicator checking the statement arguments in the solution process. Because S3 made an error in the skill process where students were wrong in calculating basic multiplication, and encoding because students did not provide an explanation for the answers they got. Even though S3 was able to determine the problem solving design to get answers, the students were wrong in the solving process.

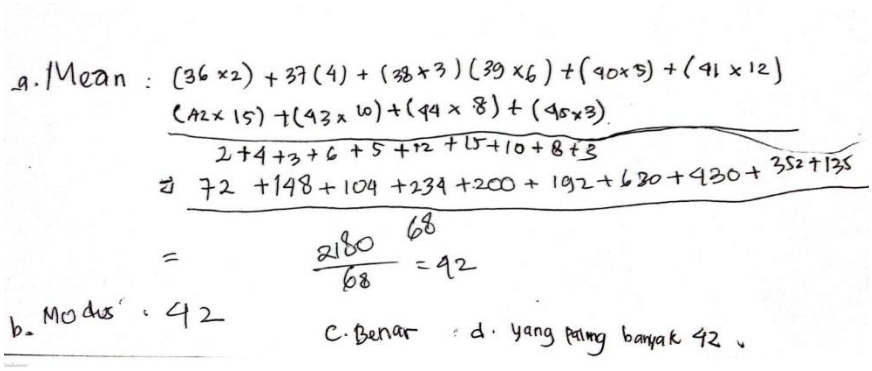

Figure 3. Answers to S3

When working on the questions, S3 showed several indicators of habits of mind, namely not being thorough because of an error in the calculation of the Mean so that the conclusion was wrong. Students do not think and communicate clearly and precisely and in metacognitive thinking they are not used to it and are not yet widespread. Based on the results of tests and

interviews, it can be seen that the factors that cause S3 to make mistakes are skill and encoding processes.

Discussions

Based on the results of the mathematical critical thinking ability test which contained 4 questions in the statistics chapter, different results were obtained. S1 with limited HoM was only able to reach indicator 1 while in indicator 2 he had not succeeded in answering the questions correctly. The developed HoM category was able to reach level 2, but failed to answer question number 3 correctly. And S3 with HoM is already proficient, able to reach indicator 3, but makes a mistake on indicator 4.

Mistakes students make based on Newman's error review are subjects with the category of limited thinking habits were only able to complete questions up to indicator 1 because they made mistakes on indicator 2 questions. Subjects could not fulfill the indicators by stating arguments. The subject made reading and processing errors. Subjects with the category of developing thinking habits were only able to solve questions up to indicator 2, because they did not meet the indicators in question 3, namely making deductions. The subject made a mistake on Comprehension and transformation. Subjects with the category of proficient thinking habits were only able to solve questions up to indicator 4 examining the argument statements in the solution process. S3 error processing skills and encoding. Students have not thought and communicated clearly and precisely and in their metacognitive thinking they have not been accustomed and have not expanded, using their limited skills and presenting reasons with various views in a clear context; provide explanations and communicate them with arguments based on their interpretations and actions.

After studying mathematical critical thinking skills, researchers interviewed several students. From the results of the interview that there are several factors that cause mistakes made by students in doing the problem. The causative factors of students' errors in thinking habits with limited categories are haste, inaccuracy, and errors in process skills, not being able to communicate with reason. Factors causing errors in thinking habits with developing categories are haste and misunderstanding Factors causing errors in thinking habits with advanced students are inaccuracy, not understanding the material and reading errors.

This research is in line with what was done by Darmawan et al. (2018); Fitriyah & Aufi (2021); Indriani et al. (2018; Lubis et al. (2021) that habits of mind can influence the completion of math problems, especially in questions of higher-order thinking skills. So that the analysis of failures carried out by students can be material for consideration and solutions to students in learning mathematics.

From these data, it is also known that the habits of mind of junior high school students are still low. This affects the level of thinking of students, especially in this case the ability to think critically mathematically which is reviewed and analyzed based on Newman's error analysis. This is in line with the research of Hanifatulianti & Sumitro (2023); Hanifah et al. (2018) that students' habits of mind affect the ability to think critically mathematically.

CONCLUSION

1. Student mistakes in completing mathematical critical thinking skills are as follows:
    a. Subjects with the category of limited thinking habits were only able to complete questions up to indicator 1 because they made mistakes on indicator 2 questions. Subjects could not fulfill the indicators by stating arguments. The subject made reading and processing errors.

b. Subjects with the category of developing thinking habits were only able to solve questions up to indicator 2, because they did not meet the indicators in question 3, namely making deductions. The subject made a mistake on Comprehension and transformation.

c. Subjects with the category of proficient thinking habits were only able to solve questions up to indicator 4 examining the argument statements in the solution process. S3 error processing skills and encoding. Students have not thought and communicated clearly and precisely and in their metacognitive thinking they have not been accustomed and have not expanded, using their limited skills and presenting reasons with various views in a clear context; provide explanations and communicate them with arguments based on their interpretations and actions.

2. Factors causing errors in limited category students in HoM are haste, imprecision, and process skill errors, not being able to communicate with reasons. Factors causing errors in the developing HoM category were haste and misunderstanding Factors causing errors in advanced HoM students were inaccuracy, not understanding the material and reading errors.

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