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MATHEMATICAL CRITICAL THINKING VIEWED BY INITIAL SKILL ON STATISTICS TOPIC

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ABSTRAK

Penelitian ini bertujuan untuk menganalisis keterampilan berpikir kritis matematis ditinjau dari kemampuan awal pada topik statistika. Kajian ini penting dilakukan karena topik statistika menuntut kemampuan menginterpretasi data, menganalisis hubungan antarinformasi, mengevaluasi strategi penyelesaian, dan menarik inferensi, sehingga kemampuan awal berperan besar dalam membentuk kualitas proses berpikir kritis siswa. Penelitian ini menggunakan pendekatan kualitatif deskriptif dengan desain intrinsic case study untuk menggali secara mendalam karakteristik berpikir kritis siswa berdasarkan kategori kemampuan awal. Subjek penelitian terdiri dari enam siswa kelas VII yang dipilih berdasarkan kategori kemampuan awal rendah, sedang, dan tinggi. Pengumpulan data menggunakan tes dan wawancara. Hasil penelitian menunjukkan bahwa (1) siswa berkemampuan awal rendah hanya mampu melakukan interpretasi, (2) siswa berkemampuan awal sedang mampu melakukan interpretasi, analisis, dan evaluasi meskipun belum lengkap, dan (3) siswa berkemampuan awal tinggi mampu memenuhi keempat indikator berpikir kritis secara lengkap. Temuan ini menegaskan pentingnya mempertimbangkan kemampuan awal dalam merancang asesmen dan pembelajaran yang menuntut keterampilan berpikir tingkat tinggi (HOTS).

Kata kunci: matematika, keterampilan berpikir kritis, kemampuan awal, topik statistika.

ABSTRACT

This study aims to analyze students' mathematical critical thinking skills in relation to their initial abilities on the topic of statistics. This investigation is essential because statistical topics require the ability to interpret data, analyze relationships between pieces of information, evaluate solution strategies, and draw inferences; therefore, initial ability plays a substantial role in shaping the quality of students' critical thinking processes. The research employed a descriptive qualitative

approach with an intrinsic case study design to explore in depth the characteristics of students' critical thinking based on their initial ability categories. The participants consisted of six seventh-grade students selected according to their levels of initial ability low, medium, and high. Data were collected through tests and interviews. The findings reveal that (1) students with low initial ability were only able to perform interpretation, (2) students with medium initial ability could perform interpretation, analysis, and evaluation though not yet completely, and (3) students with high initial ability were able to demonstrate all four indicators of critical thinking comprehensively. These results highlight the importance of considering students' initial ability when designing assessments and learning activities that demand higher-order thinking skills (HOTS).

Keywords: *mathematics, critical thinking skill, initial skill, statistics topic*.

INTRODUCTION

Mathematics learning in secondary school is still on a concrete problem that is contextual to the real life of students (Bora, 2019). Concrete problems are related to things that can be felt while contextual problems are related to what is happening around. Mathematics at this level is very important for students in developing students' rationality in analyzing and synthesizing a problem that are faced by students (Erath 2018). The practice of doing tests on students' mathematics initial skill is one of the ultimate goals of learning. The importance of mathematics learning can determine students' success in university (Kosiol, 2018). That is useful for students because learning in higher school needs good critical thinking skill to solve problems (Lyon, 2020).

Critical thinking skill is a cognitive skill in terms of describing a problem and then putting the problem back together systematically and logically so that the problem can be solved (Ennis, 1996). Critical thinking skill is also a mental process in the soul that can act beyond the available information in the form of generalizable patterns. Currently, schools are expected to educate students so that they can access knowledge, solve problems, use various ideas, and have critical thinking skill (Arisoy, 2021; Iqbal 2021).

This improvement in critical thinking skill can also improve students' skills to learn many subjects (Ragupathi, 2022). Critical thinking can be improved with the use of appropriate learning models and teaching materials. The use of various appropriate learning models is very useful in developing this critical thinking

(Calkins, 2019; Karapetian, 2020). Critical thinking can also be developed by controlling the pedagogical and psychological conditions of students while studying in the classroom (Mathews, 2019; Renatova, 2021). Students' worldviews can be formed through these conditioned learning activities and students' conscious attitudes towards social systems can also be formed.

There are 4 indicators in critical thinking (Facione, 1994), namely (1) interpretation, (2) analysis, (3) evaluation, and (4) inference. Interpretation is to understand the problem such as being able to describe the problem variables and what the problem questions are in the form of simple mathematical symbols. Analysis is to identify the relationship among concepts, statements, and questions in the form of mathematical models. Evaluation is to use the right strategy to solve the problem completely and correctly in calculations. Inference is to conclude a calculation process in the form of a solution to a problem question.

Critical thinking skill can be seen from the results of students' answers in doing higher other thinking skills (HOTs) tests. These mathematical HOTs are at cognitive level 4 (C4) to cognitive level 6 (C6) (Anderson & Krathwohl, 2001). Cognitive level C4-C6 consisting of analyzing, assessing and creating activities. Critical thinking skill is at cognitive level C4. So that students can be given practice with mathematical HOTs tests to improve their critical thinking skills (Arifin & Retnawati, 2017).

However, junior high school students have several errors in answering critical thinking problems on the topic of plane geometry (Darmawan, 2018). These errors were (1) students cannot identify the question information, (2) students do not understand the question problem, and (3) students cannot process information. Mathematical critical thinking problems are so difficult for students to solve because the learning process does not get students to answer coherently and completely.

Students are also not used to doing HOTs test so that higher-order thinking skills are very low (Saraswati, 2020). Students must be accustomed to solving problems in a coherent manner from understanding questions, planning solutions, implementing the plan, and rechecking the results of the answers. Learning should

be directed to the cultivation of concepts regarding the strategy of completing a mathematics test.

Likewise, from the results of interviews between researcher and a junior high school teacher, researcher found that many students scored below the minimum completeness criteria in mathematics. The teacher said that students were not able to work on questions that require mathematical critical thinking skills. Students were not trained to do mathematical HOTs tests but only mathematical tests according to the basic competencies of a mathematics topic.

The previous description shows that there is an imbalance between students' need for critical thinking skill and the reality of many students' skill who still do not master it. Research related to this has not yet been discussed specifically in terms of the level of learning outcomes and in the statistical material segment. Therefore, researcher is also interested in analyzing the mathematical critical thinking skill of junior high school students in terms of the initial skill in statistics topic. This research can provide an overview to the teacher about what are the strengths and weaknesses of students in doing the mathematical critical thinking skill test.

RESEARCH METHOD

This study employed a descriptive qualitative approach with an intrinsic case study design. The intrinsic case study design was chosen because the study specifically aimed to explore in depth the characteristics of students' mathematical critical thinking skills based on their initial ability categories in the statistics topic. The research subjects consisted of six students selected from a total of 33 seventh-grade students at MTs Negeri 3 Kampar. The selection of subjects was based on the results of a mathematics initial-ability pretest, which categorized students into three groups (low, medium, and high) each represented by two students and subjects were selected based on the recommendation of the mathematics teacher at the school. Data collection instruments in the form of tests and interviews. The critical thinking skill test consists of 2 questions as shown in Table 1. The interview was conducted in a semi-structured manner after the test was given.

Table 1. Critical Thinking Skill Test Items

No.	Questions
1.	In a class there are 22 students. The mean of students' mathematics test is 5 and the range is 4. If a student with the lowest score and a student with the highest score are excluded, then the average score will be 4.9. Find the lowest student score.
2.	A sample data was obtained from five observations. If the sample data mean is equal to 10, the sample data median is equal to 12, and there are three score data from sample data mode. The sample data mode is also the highest score. Determine the value of the smallest range of the sample data range!

The data were analyzed descriptively based on four indicators of students' critical mathematical thinking skills. The data were also analyzed through the stages of data reduction, data presentation, and verification or drawing conclusions, following the Miles and Huberman model. The scoring guidelines for the modified test from Karim (2015) can be seen in Table 2. The maximum score for indicator 1 (interpretation), indicator 2 (analysis) and indicator 4 (inference) is 2 points, while for indicator 3 (evaluation) is 4 points.

Table 2. Scoring Rubric of Mathematical Critical Thinking Test

No.	Indicator	Explanation	Score
1.	Interpretation	Not writing what is known and what is asked from the given question	0
		Writing down what is known and what is asked from the given question but is not quite correct	1
		Writing down what is known and asked from the given question correctly	2
2.	Analysis	Being unable to identify the relationships among the informational statements of the problem	0
		Being able to identify the relationships among the informational statements of the problem, but is not quite correct	1
		Being able to identify the relationships among the informational statements of the problem, and is correct	2
3.	Evaluation	Not using strategies in solving problems	0
		Using inappropriate and incomplete strategies in solving problems	1

		Using appropriate strategies in solving problems, but incomplete ones	2
		Using appropriate and complete strategies in solving problems, but is not quite correct	3
		Using appropriate and complete strategies in solving problems, and is correct	4
4.	Inference	Not drawing the conclusion	0
		Drawing the conclusion, but is not quite true	1
		Drawing the conclusion correctly completely in terms of question context	2

RESEARCH RESULTS AND DISCUSSIONS

There were 33 of 7th grade students of junior high school who were tested for mathematical thinking skill, and the researcher took 6 students to be analyzed descriptively. This sampling was based on the level of students' mathematics initial skill. The initial skill was divided into three categories, namely low, medium, and high. Subjects were given codes, namely S1 and S2 for students with low initial skill category, S3 and S4 for students with medium initial skill category, and S5 and S6 for students with high initial skill category (see Table 3).

Table 3. Coding of Research Subjects

No.	Subject codes	Initial skill categories
1.	S1	Low
2.	S2	Low
3	S3	Medium
4.	S4	Medium
5	S5	High
6	S6	High

Subjects S1 and S2 who were included in the category of students with low initial skill got a score of 3 for item 1, then S1 and S2 get scores of 3 and 2 respectively for item 2. In Figure 1, S1 answers item 1 by interpreting what information and what questions from item 1. S1's interpretation of item 1 was correct but S1 did not analyze the information. For the evaluation part, S1 can do it even though the results cannot answer the question. S1 also did not make any inferences about the part of the evaluation that has been done. This also happens to S2 which can only interpret.

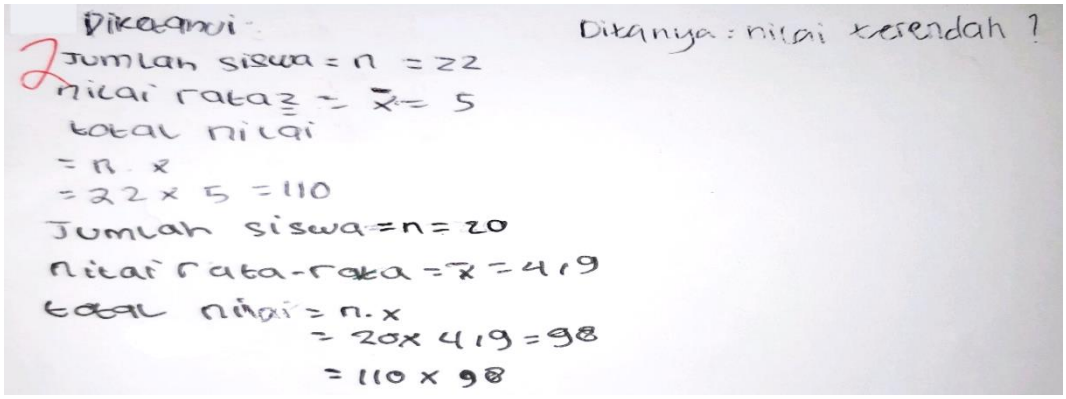

Figure 1. S1's Answer for Item 1

Subject S2 answered the item (see Figure 2) by making the wrong interpretation. The S2's interpretation was wrong on the information about the mean value, which is 10 and the sample size, which is 5. S2 thought that the mean is the same as the sample size, so that S2 gets a score for each observation data is 2. everything. S2 was also wrong in doing analysis and evaluation and did not make inferences.

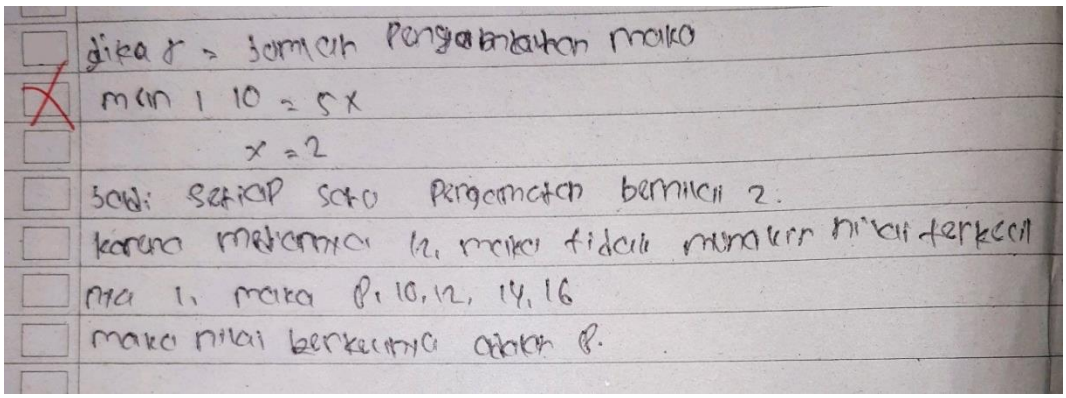

Figure 2. S2's Answer for Item 2

The results of S1 and S2 showed that students with low initial skill can only interpret correctly, and some cannot even do one of the 4 indicators of mathematical critical thinking. This result was like Mulyanto (2018) and Syarifah (2019)'s researchers which states that students with low motivation cannot identify assumptions, cannot arrange questions with reasons, and are unable to arrange answers with reasons. Likewise, with Septiana (2019) and Putri (2020)'s research which says that students with poor initial skill got a low percentage, which is below 50% for indicators of giving arguments, understanding problems, inducing assumptions, and making decisions. Both studies had similarities with the situation

in S1 and S2 where students' mathematical critical thinking skills are still low along with the low initial skill.

This study also aligns with the theoretical mechanism of metacognition. According to Facione (1994), critical thinking skills develop through metacognitive processes that allow students to monitor and evaluate their own thinking. Students with low initial ability typically lack mature metacognitive strategies, making it difficult for them to analyze information and draw logical conclusions. This is supported by Ennis (1996), who emphasizes that critical thinking requires mental regulation and stable intellectual habits—capacities that have not yet developed in students with low initial ability. Thus, the low performance of S1 and S2 is not merely due to limited knowledge but also to weak self-regulation and cognitive strategies.

For the category of students with medium initial skill, namely S3 and S4, they got a score of 7 for item 1 and a score of 6 for item 2. S3 subjects started the answer by interpreting what was known from the question well (see Figure 3). But in the analysis section, S3 did not fully explain the relationship between the initial mean score and the final mean score. Even so, S3 can still evaluate the available data so that S3 gets the right answer. For the inference part, S3 as well as S4 cannot relate the final answer to the question so they did not make inferences.

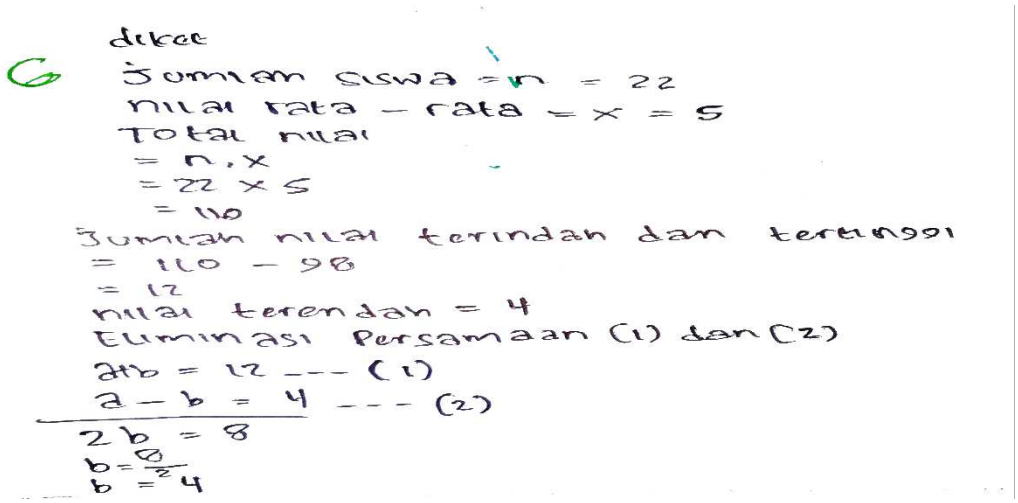

Figure 3. S3's Answer for Item 1

Subject S4 has done the interpretation for item 2 well in Figure 4. Part of the analysis was also carried out completely by S4, which S3 also did so. But S4 cannot evaluate its analysis results clearly and completely. S4 stopped at making

possible the first data score and the second data scores. S4 cannot relate the results of further analysis to the information that has been interpreted, namely the range score. So that S4 did not make inference to item 2.

Students with the medium initial skill have been able to perform indicators of interpretation and analysis well, although the analysis was still not complete. For the evaluation and inference section, also S3 and S4 were not able to complete it, because they could not relate the results of the analysis with the initial information that was interpreted previously. Problem-based learning can be a solution for students with the medium initial skill in improving evaluation and inference indicators because students can get used to linking the results of answers and initial questions to problems (Jumaisyaroh, 2014; Budayawati, 2019). This problem-based learning can also be developed by directing students to make questions from information, so that students' inference indicators can be honed (Mahmuzah, 2015; Huda, 2022).

From a theoretical standpoint, students in the medium category are in a developmental phase of critical thinking where analytical processes are becoming stable, but evaluation and inference processes have not yet become automatic. This is consistent with Facione's (1994) concept of "rational judgment," in which students in transitional stages require scaffolding to perform logical assessments and draw conclusions.

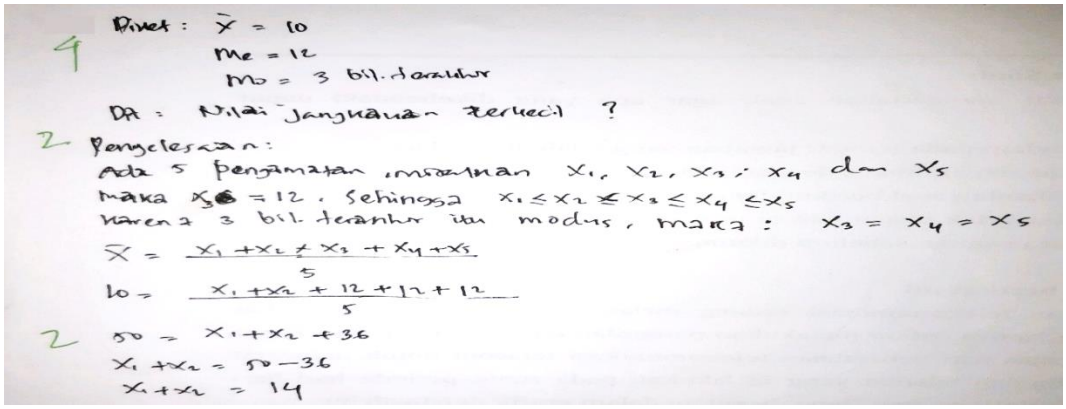

Figure 4. S4's Answer for Item 2

The last category is the category of high initial skill by S5 and S6, where they got a score of 8 for item 1 and item 2. Figure 5 shows the results of S5's answer for item 1. S5 explained the interpretation of the test information well. Then the

analysis section was carried out in full by displaying the completion flow. S5 evaluated the results of the analysis correctly until it meets the final answer. The final answer has been linked to question item 1 in the inference section. This was also done by S6 who answered correctly and completely.

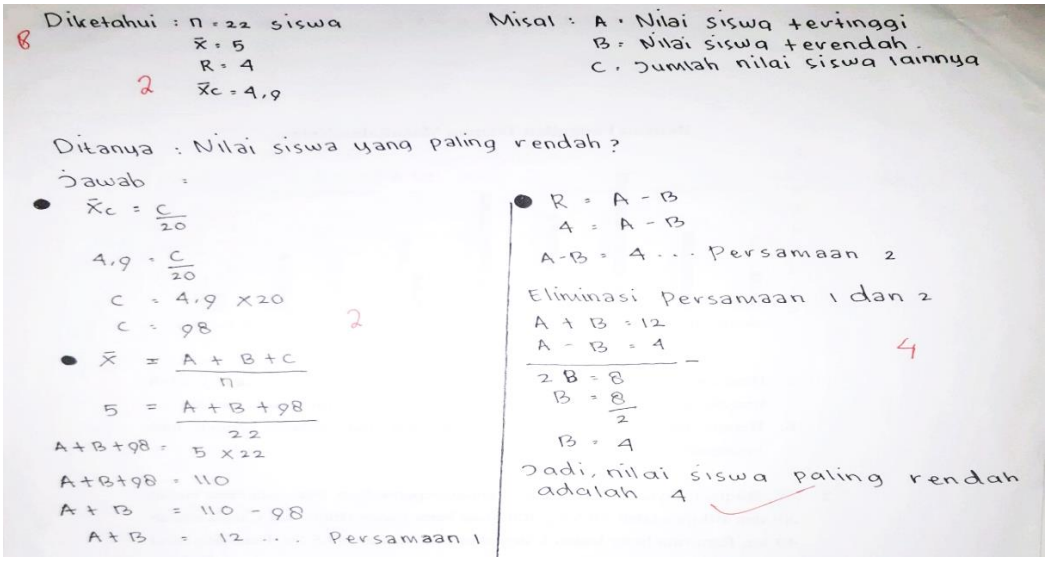

Figure 5. S5's Answer for Item 1

Subject S6 started the solution by making what was known and was asked correctly (see Figure 6). From this information, S6 made a complete analysis of the information linkage and completion flow. The evaluation carried out by S6 was correct until it reached the final correct answer. S6 can make several possibilities completely from the first and second data scores so that S6 can solve the problem. The inference results from S6 were also appropriate in linking the evaluation results and questions.

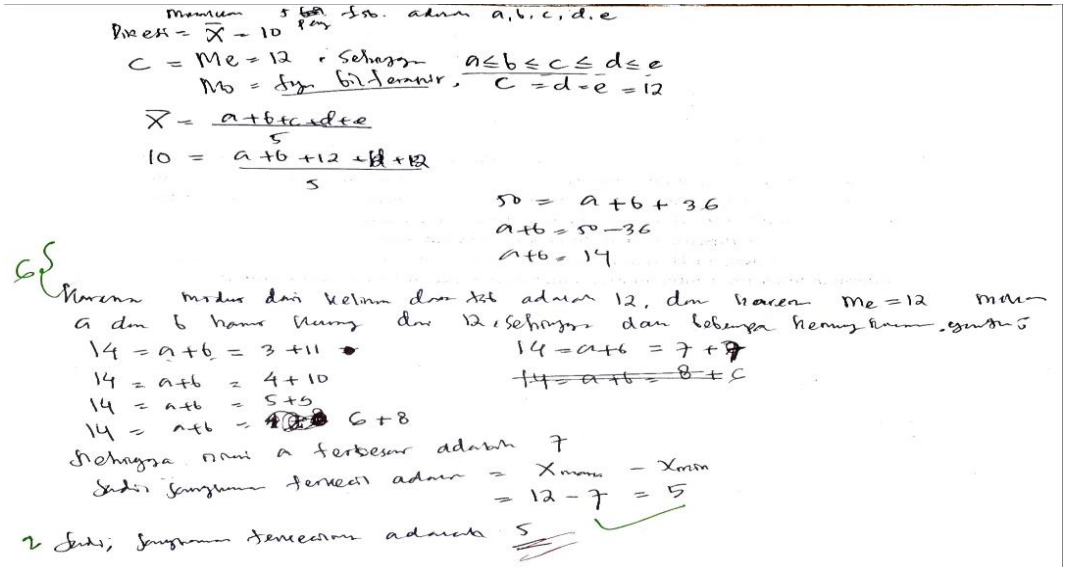

Figure 6. S6's Answer for Item 2

Students with the high initial skill have been able to perform the four indicators of mathematical critical thinking skills, namely interpretation, analysis, evaluation, and inference correctly and completely. This happens because students with the high initial skill have used mental processes in solving problems well, so that non-routine problems can be solved correctly and completely. Research is in line with research by Alexandra (2018) and Delfia (2020) that students with high critical thinking skills have indicators of focus, reasoning, clarity, and review. Likewise, Rahmawati (2019) and Razak (2017) revealed that there is a relationship between students' initial skill and critical thinking skill, so that students who have been equipped with good mathematical skill can answer problems in a detailed and complete manner.

Based on Ennis's (1996) theory, students in this category possess well-developed intellectual habits—such as seeking clarity, maintaining open-mindedness, and constructing evidence-based reasoning—allowing them to solve non-routine problems thoroughly. Thus, their high performance is not solely due to mastery of mathematical content but also due to the presence of critical-thinking dispositions embedded in their cognitive processes.

The findings of this study carry important instructional implications. Teachers must adapt learning stimuli so that each initial-ability group receives appropriate cognitive challenge. Teachers can enhance the critical-thinking

indicators of low-ability students through metacognitive strategy scaffolding, promote evaluation and inference activities for medium-ability students, and maintain high-level challenges for high-ability students. In other words, teachers need to align the cognitive level of tasks and the learning model with students' initial abilities to ensure that all groups develop critical-thinking skills effectively.

CONCLUSIONS

Conclusions in the form of solutions to the problems and research objectives in the introduction. In this section, contains a summary of results but not a repetition of the results of research and discussion. Conclusions are enough to write in one paragraph with a composition of 5% of the total pages of the article. It is better not to write conclusions in the form of numbering. However, if forced to exist, numbering is still written in paragraph form like the example in the introduction.

ACKNOWLEDGEMENTS

The results showed that there were several patterns of students with different initial skill, namely low, medium, and high in terms of mathematical critical thinking skills. These patterns are seen from the four indicators of mathematical critical thinking skills, namely interpretation, analysis, evaluation, and inference. Based on this results and discussion, the researchers found the following patterns (1) students with the low initial skill could not go further than interpreting because they were not used to doing mental processes in critical thinking on non-routine problems, (2) students with the moderate initial skill could interpret, analyze, and evaluate well, but the evaluation is incomplete, because they were not accustomed to linking the mathematical operation process and what was being asked, and (3) students with the high initial skill can interpret, analyze, evaluate, and inference with correct and complete because they can use the mental processes of mathematical critical thinking skills well even though they were not accustomed to working on non-routine problems.

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