p-ISSN: 2086-4280
e-ISSN: 2527-8827

Assessing Critical Thinking Abilities in Solving Mathematics Number Pattern Problems Among Junior High School Students

Shafira Meiria Rahmasari[1], Zaenuri[2*], Iwan Junaedi[3], Adi Nur Cahyono[4]

Mathematics Education, Universitas Negeri Semarang
Gunung Pati, Semarang, Central Java, Indonesia
[1]*shafirameiria@students.unnes.ac.id*; [2*]*zaenuri.mipa@mail.unnes.ac.id*;
[3]*iwanjunmat@mail.unnes.ac.id*; [4]*adinurcahyono@mail.unnes.ac.id*

Article received: 26-02-2025, revision: 20-03-2025, published: 30-04-2025

Abstrak

Kemampuan berpikir kritis siswa dalam matematika masih rendah. Penelitian ini bertujuan mengeksplorasi kemampuan berpikir kritis siswa dalam matematika, dengan fokus pada masalah pola bilangan, menggunakan pendekatan deskriptif kualitatif. Subjek penelitian yaitu tiga belas siswa pada salah satu SMP di Kabupaten Cirebon. Instrumen yang digunakan adalah tes kemampuan berpikir kritis tentang pola bilangan yang terdiri dari dua soal utama dengan empat sub pertanyaan dan pedoman wawancara. Data dikumpulkan melalui tes tertulis dan wawancara kemudian dianalisis melalui reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan kemampuan berpikir kritis siswa dalam menyelesaikan masalah matematika hanya mencapai tahap rata-rata hingga di bawah rata-rata pada seluruh indikator kemampuan berpikir kritis dalam matematika yaitu interpretasi, analisis, evaluasi, dan inferensi. Penelitian ini berkontribusi memberikan gambaran mengenai kemampuan berpikir kritis siswa dalam menyelesaikan masalah matematika pada materi pola bilangan yang dapat menjadi dasar dalam merancang strategi pembelajaran yang lebih efektif serta pengembangan instrumen asesmen berbasis indikator berpikir kritis.
Kata Kunci: Deskriptif Kualitatif; Kemampuan Berpikir Kritis; Pola Bilangan; Siswa SMP

Abstract

Students' critical thinking abilities in mathematics remain low. This study aims to explore students' critical thinking abilities in mathematics, focusing on number pattern problems, using a qualitative descriptive approach. The participants were thirteen students from one Junior High School in Cirebon Regency. The instruments used included a critical thinking test on number patterns containing two main items with four sub-questions, and interview guidelines. Data were collected through written tests and interviews, and analyzed through data reduction, data display, and concluson drawing. The results show that most students achieved only average to below-average performance across indicators of critical thinking abilities in mathematics namely interpretation, analysis, evaluation, and inference. This study contributes to provide a detailed description of Junior High School students' critical thinking profiles in solving number pattern problems, which can development of more effective instructional strategies and critical thinking based assessment.
Keywords: Qualitative Descriptive; Critical Thinking Abilities; Number Patterns; Junior High School Students

I. INTRODUCTION

A key component of developing knowledge and skills for the twenty-first century is education. According to Mahmud & Wong (2022), 21st century skills encompass a suite of competencies such as critical thinking, problem solving, data literacy, collaboration, and creativity that are essential for learners to succeed in higher education and the workforce. School serves a central function in nurturing these competencies through curriculum design and pedagogical practice. Similarly, (Kusuma & Fauzi, 2023). emphasize that high-quality education systems, particularly within mathematics learning, foster students' critical thinking by incorporating inquiry-based learning strategies and collaborative problem-solving tasks. One of the thinking abilities this is priority for students to enhance to fulfil skills in the 21st century is critical thinking (Hsu et al., 2022; Hujjatusnaini et al., 2022). Higher order thinking, or critical thinking, is seen as a goal for education by 2050 (International Commision, 2021) which if taught well, it will encourage reasoning and skills to solving problem and enhance learning. Now, curriculum for mathematics education prioritize enhancing students' critical thinking abilities accross the globe (Weng et al., 2022).

Students who develop critical thinking abilities demonstrate stronger logical reasoning and systematic analysis (Lessy et al., 2021), make better-informed decision by evaluating multiple alternatives (Hayati et al., 2023), efficiently integrate and relate different ideas, and conduct comprehensive assessment of complex problembs as part of their reasoning process (Hačatrjana & Namsone, 2024). Students who have critical thinking abilities approach problems carefully to ensure that the conclusions drawn are accurate and offer logical answer (Barestova et al., 2022). Critical thinking abilities make students accustomed to stimulate a rational attitude in providing the best alternative choice (Plummer et al., 2022). Students that possess critical thinking abilities can also approach problems methodically, overcome obtacles in an orderly way, ask creative questions, and provide original solution (Sasson et al., 2022; Ramirez et al., 2022).

Recent studies such as Ningrum & Murti, (2023) show that contextual learning models, which embed daily-life examples and real-world scenarios, effectively enhance students' critical thinking. Similarly, (Cahyani & Setyaningsih, 2024) demonstrate that problem-based learning centered on contextual mathematics problems significantly improves students' reasoning and analytical skills, particularly when learning mathematics, as it is crucial for them to have and stimulate these abilities to deal with everyday problems (Wang et al., 2022). Since mathematics is one of the fundamental sciences for developing thinking abilities, it is a topic that has a significant impact on how students develop into qualified individuals. These abilities include the capacity for critical analysis, creative thought, and problem solving. In the era of globalization and rapid technological development, the ability to think critically in mathematics has become an indispensable skill. Critical thinking abilities in mathematics teach students to think logically, analytically, and creatively in solving problems.

p-ISSN: 2086-4280
e-ISSN: 2527-8827

Critical thinking, according to Facione (2015), is the ability to control oneself when making decision that leads to interpretation, analysis, evaluation, and inference. The core critical thinking ability according to Facione (2015) is interpretation to understand the information of problems; analysis to understand something more deeply through information and data; inference to derive conclusions from gathering of data and information; evaluation in order to gauge the results generated; explanation that lays out the facts, logic, and supporting data, and matching as the final stage namely validation. Ennis (2011) adds that critical thinking is the capacity for thoughtful, reasonable thought that is centered on one's beliefs or actions. Critical thinking abilities (Ennis, 2011) encompass a range of talents such as basic clarification skills, basic decision making, concluding, providing further explanations, estimating and integrating, as well as additional abilities. According to Jacob & Sam (2008), Critical thinking abilities include the ability to clarification namely formulating the main issues, assessment namely the ability to provide reasons to produce correct arguments, inference namely drawing clear and logical conclusions from the results of the investigation, strategy namely solving problems with various alternative solutions based on concepts. Meanwhile according to Angelo (Santoso, 2018), Critical thinking abilities include analyze, synthesize, problem solving, the ability to conclude, and the ability to evaluate.

In the field of education, the value of critical thinking abilities in mathematics has become widely recognized. This is particularly true for Junior High School students, who are still learning the fundamentals of the subject. At this stage, students start to come across increasingly difficult and in-depth mathematical content. Their aptitude for higher level mathematics in addition to critical thinking generally can be greatly impacted by the process of building mathematical critical thinking abilities at Junior High School. Consequently, the cornerstones of success in any career are critical thinking and problem solving. The sharper a student's mathematical critical thinking abilities are the more capable of solving problems and formulating arguments by utilizing a broad knowledge base (Apiati & Hermanto, 2020; Afriansyah et al., 2021). When solving problems, students stimulate mathematical critical thinking abilities related to advanced mathematics. However, previous studies show that critical thinking abilities in mathematics are still a major concern in the world of education. Numerous students encounter diverse challenges when attempting to solve mathematical problems, prompting inquiries regarding the variables influencing capacity for critical thinking in mathematics learning. The need to determine the degree to which Junior High School students' mathematical critical thinking abilities have grown is further exacerbated by curriculum modifications that place an increased emphasis on problem solving, critical thinking, and deep comprehension.

The problem explanation above served as the basis for this research, which examines Junior High School students' mathematical critical thinking abilities. The

preparation of this analysis took into account the primary components offered by Facione (2015), namely interpretation, analysis, evaluation, and inference. The main aim of this research is to provide in depth insight into the extent to which student at the Junior High School level have developed their critical thinking abilities in mathematics. This research also aims to analyze the factors that influence Junior High School students' critical thinking abilities in mathematics. These factors may include teaching methods, learning environment, student motivation, and other social factors. Understanding these factors can help mathematics teachers design more effective teaching strategies to develop students' critical thinking abilities. The results of this study are expected to have a major impact on initiatives aimed at enhancing Junior High School mathematics instruction. In contrast to previous studies that broadly examined students' critical thinking abilities, this study provides a focused and detailed analysis of critical thinking indicators using Facione's indicator of critical thinking abilities applied to number pattern problems among Junior High School students in Cirebon Regency. This localized exploration fills a gap in the literature and presents a contextual understanding that can guide the development of teaching strategies and assessment. Recent studies have also emphasized the growing need for integrating higher-order thinking, including critical thinking into mathematics learning (Saepuloh et al., 2022; Wiradinata et al., 2023). These studies, indexed in Scopus, highlight how mathematics reasoning and structured problem-solving approaches, particularly within pattern-based question can serve as powerful tools for cultivating students' analytical and evaluative skills. Such efforts align with international educational goals to equip learners with relevant cognitive competencies to navigate uncertainly and complexity in the 21st century.

In addition, this research has high relevance in the context of improving the quality of mathematics education at the Junior High School level and in equipping students with critical thinking abilities that will help them succeed in various aspects of life.

II. METHOD

This research is a qualitative descriptive study. The participants consisted of thirteen eighth-grade students from one of the Junior High School in Cirebon Regency. The selection of research subjects was caried out using purposive sampling, specifically involving students who had already received instruction on number pattern material and based on the consideration and recommendation by their mathematics teacher. The object of this research is students' critical thinking abilities in solving mathematics problems, specifically on number pattern material, based on indicator of critical thinking abilities

The data collection technique used in this study involved (1) a written test instrument in the form of essay questions designed to reveal various aspects of critical thinking, and (2) interview guidelines to further explore students' reasoning processes. The research instruments were validated by experts in mathematics education through two stages of expert review to ensure

p-ISSN: 2086-4280
e-ISSN: 2527-8827

content validity and appropriateness. Ethical approval for the study was obtained from the school principal, and informed consent was collected from all participants and their guardians. Data obtained were analyzed through the stage of data reduction, data display, and conclusion drawing.

According to Facione (2015), as outlined in Tabel 1 below, test results serve as the basis for scoring rubric aligned with specific indicators of critical thinking abilities: interpretation, analysis, evaluation, and inference. These indicators are used to evaluate and collect data on students' critical thinking abilities in solving mathematical problems. The results obtained provide a comprehensive profile of students' critical thinking abilities that can be used to inform instructional practices and assessment design.

Table 1.
Guidelines for Scoring Critical Thinking Abilities

Indicators	Information	Score
Interpretation	Not writing what is known and asked	0
	Write what is known and asked but is not correct	1
	Write only what is known or what is asked accurately	2
	Write what is known and asked but is incomplete	3
	Write what is known and asked about the question correctly and completely	4
Analysis	Not making a mathematical model from the problem given	0
	Making a mathematical model from the problem given but not correctly	1
	Making a mathematical model from the problem given correctly without giving an explanation	2
	Making a mathematical model from the problem given correctly but there is an error in the explanation	3
	Making a mathematical model from the problem given correctly and giving a correct and complete explanation	4
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 or using inappropriate but complete strategies in solving problems	2
	Using appropriate strategies in solving problems, complete but making mistakes in calculations or explanations	3
	Using appropriate strategies in solving problems, complete and correct in carrying out calculations or explanations	4

Indicators	Information	Score
Inference	Does not make a conclusion	0
	Makes a conclusion that is inaccurate and does not fit the context of the question	1
	Makes a conclusion that is not correct even though it is adapted to the context of the question	2
	Makes a conclusion that is correct in accordance with the context but incomplete	3
	Makes a conclusion that is correct in accordance with the context of the question and is complete	4

After making corrections to the student work, the data analysis technique examines the students' capacity for critical thinking in in solving mathematical problems. Data on students' critical thinking abilities in solving mathematical problems score were analyzed using the percentage formula, as follows.

$$\text{Score} = \frac{\text{students' score}}{\text{ideal score}} \text{ x } 100$$

The critical thinking ability in solving mathematical problem values obtained from the calculations are then qualified according to the following table.

Table 2.
Criteria for Students' Critical Thinking Abilities
Setiana (2021)

Score	Criteria
$80 < X \leq 100$	Very good
$60 < X \leq 80$	Good
$40 < X \leq 60$	Average
$20 < X \leq 40$	Below average
$0 < X \leq 20$	Very bad

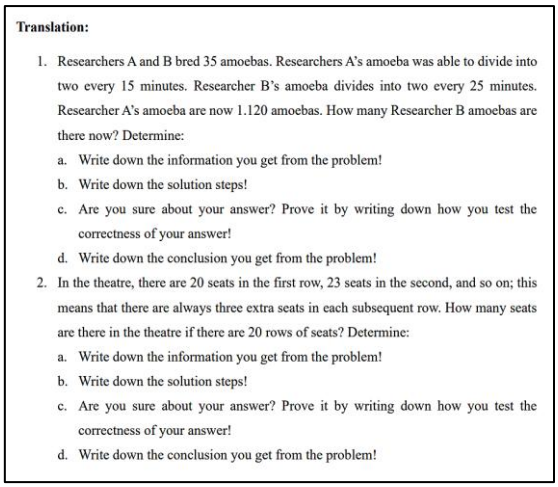
III. Result and Discussion

This section presents and interprets the findings of the study in relation to the research objective, which is to analyze students' critical thinking abilities in solving mathematical problems on number pattern material. The discussion is structured around the critical thinking indicators proposed by Facione namely interpretation, analysis, evaluation, and inference, and connects the results with relevant theories and previous reseach. The analysis focused on students' written responses and categorizes their performance based on levels of critical thinking ability. This provides a comprehensive understanding of how students think, reason, and make decisions when solving mathematical problems. Furthermore, this section highlights the factors that may influence students' critical thinking abilities and discusses the implications of these findings for mathematics teaching and assessment practices.

A. Result

This research was conducted to describe students' mathematical critical thinking abilities through solving problems regarding number pattern. The indicator that is the basis for student assessment is the suitability of students answers with the steps in critical thinking, namely interpretations, analysis, evaluation, and inference. Based on indicator of critical thinking abilities, a critical thinking test instrument containing the following questions is used to assess students' critical thinking ability.

p-ISSN: 2086-4280
e-ISSN: 2527-8827



Translation:

1. Researchers A and B bred 35 amoebas. Researchers A's amoeba was able to divide into two every 15 minutes. Researcher B's amoeba divides into two every 25 minutes. Researcher A's amoeba are now 1.120 amoebas. How many Researcher B amoebas are there now? Determine:
   a. Write down the information you get from the problem!
   b. Write down the solution steps!
   c. Are you sure about your answer? Prove it by writing down how you test the correctness of your answer!
   d. Write down the conclusion you get from the problem!
2. In the theatre, there are 20 seats in the first row, 23 seats in the second, and so on; this means that there are always three extra seats in each subsequent row. How many seats are there in the theatre if there are 20 rows of seats? Determine:
   a. Write down the information you get from the problem!
   b. Write down the solution steps!
   c. Are you sure about your answer? Prove it by writing down how you test the correctness of your answer!
   d. Write down the conclusion you get from the problem!

Figure 1. Students' Critical Thinking Ability Test

Based on the results obtained from the implementation of the test instrument, Table 3 below presents the criteria for assessing students' critical thinking abilities scores, categorized according to each indicator of critical thinking ability in solving mathematics problems. This indicator include interpretation, analysis, evaluation, and inference as outlined in Facione's framework. The scoring criteria are designed to reflect students' performance levels in each aspect of critical thinking. Furthermore, Table 4 displays the percentage distribution of students' critical thinking ability score in solving mathematics problems. This data serves as a basis for understanding the extent to which students have achieved the expected competencies and highlights areas that require further instructional attention.

Table 3.
Students' Score Gain

Critical Thinking Indicators	Score	Criteria
Interpretation	37.5	Below average
Analysis	38.46	Below average
Evaluation	40.38	Average
Inference	49.04	Average

The average score for the mathematical critical thinking ability of grade VIII students of one of Junior High School in Cirebon District is 41.35 in the average criteria. This is also supported by several student answers which will be presented in the discussion section.

Table 4.
Percentage of Students' Critical Thinking Ability

Score	Criteria	Frequently	Percentage
$80 < X \leq 100$	Very good	0	0%
$60 < X \leq 80$	Good	0	0%
$40 < X \leq 60$	Average	6	46.15%
$20 < X \leq 40$	Below Average	5	38.46%
$0 < X \leq 20$	Very bad	2	15.39%

Based on Table 4 above, it can be seen that there were no students who ware in the very good criteria and have good critical thinking ability. The majority of students only have average criteria of critical thinking abilities in solving mathematics number pattern problems, there were also students who have below average and very bad critical thinking ability criteria. This suggests that students have not yet mastered the expected competencies in mathematical critical thinking, particularly in the interpretation and analysis aspects.

To support the quantitative data, further descriptive analysis of students' written responses and interview results revealed several common challenges. Many students failed to accurately identify the known and asked information (interpretation), struggles to construct appropriate mathematical models (analysis), applied strategies that were incomplete or inappropriate (evaluation), and had

difficulty formulating valid conclusions (inference). These difficulties indicate a need for more targeted instructional support focused on strengthening each dimension of critical thinking in mathematics.

These results suggest a considerable gap between the intended learning outcomes of the mathematics curriculum and the actual student performance in critical thinking. The predominance of "average" and "below average" performance levels across all indicators highlights a potential misalignment between instructional methods and the development of high order thinking skills. This emphasizes the urgency for instructional reform that explicitly targets critical thinking development in everyday mathematics lesson.

B. Discussion

Based on the scores obtained, then the students' abilities in solving questions about the number patterns are analyzed. The following is a description of the analysis of indicators of mathematical critical thinking abilities.

1. Indicator 1: Interpretation

Interpreting is done by writing down what is known and what is asked in the question appropriately. Based on Table 3, it is known that the interpreting indicator is classified as below average at 37.5. This is show that students grade VIII are below average in understanding problems by determining what is known and what is asked about the problem. Many students make mistakes in understanding the problem in the question, as shown in Figure 2.

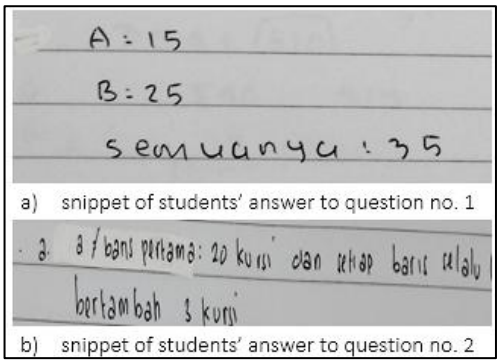


Figure 2. Excerpt of Students' Answer in the Interpretation Stage

In Figure 2, it can be seen that students tried to write down what was known or asked in the problem, but it was incomplete. Students only write one of the known from the problem, while there is some information contained in the question. Based on the results, it can be seen that students do not understanding the problem. The same thing is obtained from the results of Zuliyanti et al. (2023) that students make mistakes on the interpretation indicator because students are not careful in reading the problem. According to Facione (2015), the ability to interpret information correctly is foundational for subsequent stages of critical thinking such as analysis and inference. Students' difficulty in identifying what is known and asked suggests a need for instructional scaffolding in decoding problem contexts.

However, there were two students who met the interpretation indicator for mathematical critical thinking ability with a score of 3 and one student who met the interpretation indicator with a score of 4. Students who met the interpretation indicators get a score of 3 because students were able to write down what was known and asked in the question but incomplete, and students who met the interpretation

p-ISSN: 2086-4280
e-ISSN: 2527-8827

indicator with a score of 4 because student can write down what they known and asked in the question completely.

2. Indicator 2: Analyze

In the analysis step, the relationship between the problems' statements, questions, and concepts is determined by creating mathematical models and providing pertinent justifications. Indicator analyzing in Table 3 is in below average criteria with a value of 38.46. This show that students grade VIII are still very lacking in identifying the relationship between the statement, questions, and concepts given by making mathematical models. The errors found at this stage can be seen in Figure 3.

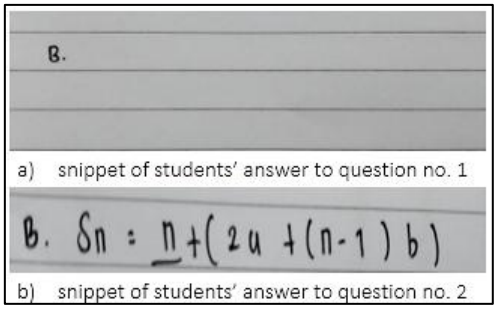


Figure 3. Excerpt of Students' Answer in the Analyze Stage

Figure 3 illustrates how students can create mathematical models, albeit with less precision. Some students have written formulas, but they are not accurate, and some students do not record their formulas at all. The same thing was also found from research by Sari & Juandi (2023) that students lack of understanding when determining the initial formula and determining the solution systematically. According to Facione (2015), analysis refers to the process of identifying intended and actual inferential relationships among statements, concepts, descriptions, and questions. Students' inability to construct appropriate mathematical models shows a weakness in this process.

But there were four students who got a score of 4 in the indicator analysis for question number 2. The students who got a score of 4 because the students were able to create mathematical models correctly and provide complete explanation.

3. Indicator 3: Evaluation

After analyzing, then the next step is to evaluate, which involves using appropriate and accurate strategies in performing calculation to solve the problem correctly. Table 3 shows that evaluation indicator falls into the average criteria with a value of 40.38. This indicates that class VIII students still demonstrate significant limitations in selecting the right strategy, executing complete and accurate procedures, and checking their solution. At this stage the mistakes made by students generally include using incorrect strategies, skipping crucial steps, or failing to verify their calculations. The errors found at this stage can be seen in Figure 4.

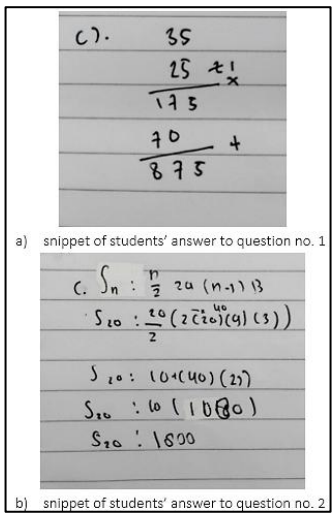


Figure 4. Excerpt of Students' Answer in the Evaluation Stage

In Figure 4, it can be seen that students perform calculations without writing down

the concepts or formulas used. There are also students who write down the concepts and formulas used and perform calculations but the formula used is wrong so that the answer results are less precise.

But there were also six students who get a score of 4 in the indicator evaluation for question number 2. Students with this score were able to use appropriate strategies in solving problems, complete and correct in carrying out calculations or explanations. Evaluation, as Facione (2015) defines, is the ability to assess the credibility of statements and the logical strength of the relationships among them. In the context of mathematics, this includes selecting the most efficient and appropriate problem-solving strategies. The students' errors in using incorrect or incomplete strategies indicate a lack of awareness, students are not sufficiently evaluating the adequacy of their methods.

4. Indicator 4: Inference

In this indicator, students check results by writing the right conclusion. From the results obtained in Table 3 for the indicator inference is 49.04 in average criteria. The errors found at this stage can be seen in Figure 5.

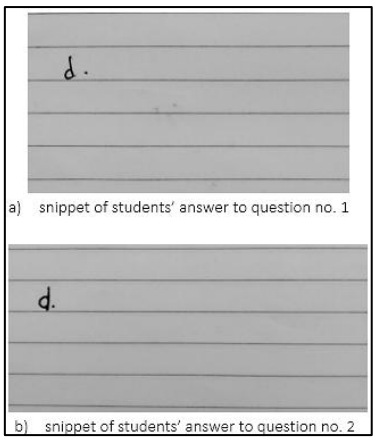


Figure 5. Excerpt of Students' Answer in the Inference Stage

In Figure 5, it can be seen that many students do not write conclusions, there are only a few students who write conclusions correctly. Students only work on problems up to the evaluation stage. The inference indicator reached average criteria because of the low students' ability in the indicators of analyzing and evaluating which affects the students' ability in making appropriate conclusions. Facione (2015) describes inference as the ability to draw reasonable conclusions from evidence and assumption. The inability of students to draw proper or complete conclusions is a consequence of their struggle in prior cognitive steps, especially evaluation and analysis.

From some snippets of students' answer and the results of the analysis show that students' mathematical critical thinking abilities are still in average criteria with score of 41.35. The findings of this study indicate that while some students achieved an average level of critical thinking, the majority performed below expectations. Compared to more recent investigations by Sari & Juandi (2023) and Zuliyanti et al. (2023), similar difficulties, especially in the analysis indicator were consistently observed. This suggests that these aspects are persistently difficult for students, regardless of context.

The analysis indicator was notably the weakest among all, with an average score of only 38.46. This may reflect a lack of instructional emphasis on mathematical modeling and problem representation during regular teaching session. In many classrooms, students are still accustomed to procedural practice rather than inquiry-based learning which is more aligned with

p-ISSN: 2086-4280
e-ISSN: 2527-8827

the development of analytical skills (Saepuloh et al. 2022).

The findings of student interviews, which indicate that students struggle and do not comprehend the assigned issues since they are accustomed to working on problems requiring this level of problem-solving ability, are also consistent with the analysis of student work. This makes students find it difficult to write what is known and asked in the problem because students usually only work on routine problems or problems that are the same as the examples given, students have difficulty converting story problems into mathematical models, applying the formulas used appropriately, and providing conclusions to the results of their work. Based on the results of this study, things that can be done to improve mathematical critical thinking abilities are students need to often practice working on problems so that students are practiced to apply the concepts they have, teachers also need to apply appropriate learning strategies.

IV. CONCLUSION

Junior High School students in Cirebon Regency are included in the average criteria for mathematical critical thinking abilities with an average score of 41.35. The average indicator of interpretation is 37.5, analysis indicator 38.46, evaluation indicator 40.38, and inference indicator 49.04. The mistakes that students make include writing the known and asked question in the problem but leaving it unanswered, creating a mathematical model and making it permissive but still erroneous, performing calculations without nothing the formula used, and writing formulas but using the incorrect formula. Few students accurately wrote their conclusions, and several students did not write any at all.

This study revealed that Junior High School students demonstrated varying degrees of critical thinking ability in solving number pattern problems, with majority performing at average or below-average levels. Among the four critical thinking indicators, interpretation and analysis were the weakest, highlighting the need for more structured learning interventions.

Theoretically, this study enriches understanding of students' mathematical thinking abilities in a specific topic area, namely number patterns, using critical thinking framework. Practically, these findings indicate that students are not accustomed to working on non-routine issue, which is something that students should get used to in order to improve their mathematical critical thinking abilities. The findings recommend that teachers emphasize open-ended and contextual problems, supported assessment aligned with each indicator of critical thinking and use a variety of learning models in the classroom. Monrat et al. (2022) also emphasize that open-ended, student-centered task based on learning preference can significantly improve critical thinking, particularly in the analysis domain.

Given the limitations in sample size and school scope, future research should involve multiple schools and consider mixed-methods approached to better generalize the findings and investigate causal relationships between instruction and critical thinking development.

ACKNOWLEDGEMENT

The authors would like to thank to the Universitas Negeri Semarang and STAI Al-Bahjah Cirebon. The author express gratitude to each and every one of the study participants. The study was supported by STAI Al-Bahjah Cirebon and Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang.

REFERENCES

Afriansyah, E. A., Herman, T., & Dahlan, J. A. (2021, February). Critical thinking skills in mathematics. In *Journal of Physics: Conference Series* (Vol. 1778, No. 1, p. 012013). IOP Publishing.

Apiati, V., & Hermanto, R. (2020). Kemampuan berpikir kritis peserta didik dalam memecahkan masalah matematik berdasarkan gaya belajar. *Mosharafa: Jurnal Pendidikan Matematika*, *9*(1), 167-178. https://doi.org/10.31980/mosharafa.v9i1.601

Barestova, A., Kolosov, S., Tsvetkova, M., & Grib, E. (2022). Academic Motivation as a Predictor of the Development of Critical Thinking in Students. *Journal of Applied Research in Higher Education*, *14*(3), 1041-1054. https://doi.org/10.1108/JARHE-02-2021-0081

Cahyani, V. F., & Setyaningsih, R. (2024). The Implementation of Problem-Based Learning to Enhance Critical Thinking Skills in Solving Contextual Mathematics Problems. *DIDAKTIKA: Jurnal Penelitian Tindakan Kelas*, *2*(2), Article 2. https://doi.org/10.63757/jptk.v2i2.29

Ennis, R. (2011). Critical Thinking: Reflection and Perspective Part II. *Inquiry: Critical Thinking Across The Disciplines*, *26*(2), 5-19.

Facione, P. A. (2015). *Critical Thinking: What it is and Why it Counts*. Insight Assessment.

Hačatrjana, L., & Namsone, D. (2024). Breaking Down the Concept of Students' Thinking and Reasoning Skills for Implementation in the Classroom. *Journal of Intelligence*, *12*(11), Article 11. https://doi.org/10.3390/jintelligence12110109

Hayati, R., et al. (2023). *Decision-Making Exercises: Challenge Students to Evaluate Various Options, Predict Outcomes, and Justify Decisions Using Logical Reasoning and Evidence. Exploring Methods for Assessing Critical Thinking*. ResearchGate.

Hsu, F. H., Lin, I. H., Yeh, H. C., & Chen, N. S. (2022). Effect of Socratic Reflection Prompts via Video-Based Learning System on Elementary School Students' Critical Thinking Skills. *Computers and Education*, *183*(2022) 104497. https://doi.org/10.1016/j.compedu.2022.104497

Hujjatusnaini, N., Corebima, A. D., Prawiro, S. R., & Ghofur, A. (2022). The Effect of Blended Project-Based-Learning Integrated with 21st Century Skills on Pre-Service Biology Teachers' Higher-Order-Thinking Skills. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 104-118. https://doi.org/10.15294/jpii.v11i1.27148

International Commission on the Futures of Education Commission. (2021). *Reimagining Our Futures Together: A New Social Contract for Education*. UNESCO.

Jacob, S. M., & Sam, H. K. (2008). Measuring Critical Thinking in Problem Solving Through Online Discussion Forums in First Year University Mathematics. *Proceedings of the International MultiConference of Engineers and Computer Scientists*, *1*(2008), 19-21.

Kusuma, R., & Fauzi, A. (2023). Teaching and Learning in the 21st Century: Integrating Technology and Pedagogical Innovation. *International Journal of Post Axial: Futuristic Teaching and Learning, 3*(1). https://doi.org/10.59944/postaxial.v3i1.415

Lessy, S., et al. (2021). *In Critical Thinking, a Person Makes Decisions and Successfully Solves Problems by Analysing One or More Ideas Logically and Systematically*. Review of Education.

Mahmud, M. M., & Wong. S. F. (2022). Digital age: The Importance of 21st Century Skills among the Undergraduates. *Frontiers in Education, 7*(950553). https://doi.org/10.3389/feduc.2022.950553.

Monrat, N., Phaksunchai, M., & Chonchaiya, R. (2022). Developing Students' Mathematical Critical Thinking Skills Using Open-Ended Questions and Activities Based on Student Learning Preferences. *Education Research International, 2022*(1). https://doi.org/10.1155/2022/3300363

Ningrum, A. W., & Murti, R. C. (2023). Contextual Learning Models in Improving Elementary School Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA, 9*(5), 48–53. https://doi.org/10.29303/jppipa.v9i5.2360.

Plummer, K. J., Kebritchi, M., Leary, H. M., & Halverson, D. M. (2022). Enhancing Critical Thinking Skills Through Decision-Based Learning. *Innovative Higher Education*, *47*(4), 711-734. https://doi.org/10.1007/s10755-022-09595-9

Ramirez-Montoya, M. S., Castillo-Martinez, I. M., Sanabria-Z, J., & Miranda, J. (2022). Complex Thinking in the Framework of Education 4.0 and Open Innovation: A Systematic Literature Review. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(1), 1-15. https://doi.org/10.3390/joitmc8010004

Saepuloh, A., Prabawanto, S., & Fitriyani, R. (2022). Enhancing Students' Critical Thinking Skills Through Number Pattern Tasks Based on Ethnomathematics. *Journal of Physics: Conference Series*, 2320(1), 012017. https://doi.org/10.1088/1742-6596/2320/1/012017.

Santoso, H. (2018). *Pengaruh penggunaan laboratoriun riil dan laboratorium virtual pada pembelajaran fisika ditinjau dari kemampuan berpikir kritis siswa*. Tesis Program Studi Pendidikan Sains: Universitas Sebelas Maret.

Sari, R., & Juandi, D. (2023). Improving Students' Critical Thinking Skills in Mathematics Education: A Systematic Literature Review. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *7*(1), 845-861. https://doi.org/10.31004/cendekia.v7i1.2091

Sasson, I., Yehuda, I., Miedijensky, S., & Malkinson, N. (2022). Designing New Learning Environments: A Innovative Pedagogical Perspective. *The Curriculum Journal, 33*(1), 61-81. https://doi.org/10.1002/curj.125

Setiana, D. S., Purwoko, R. Y., & Sugiman, S. (2021). The Application of Mathematics Learning Model to Stimulate Mathematical Critical Thinking Skills of Senior High School Students. *European Journal of Educational Research, 10*(1), 509-523. https://doi.org/10.12973/eu-jer.10.1.509

Wang, D., Liu, H., & Hau, K. T. (2022). Automated and interactive Game-

Based Assessment of Critical Thinking. *Education and Information Technologies*, *27*(4), 4553-4575. https://doi.org/10.1007/s10639-021-10777-9

Weng, X., Cui, Z., Ng, O. L., Jong, M. S. Y., & Chiu, T. K. F. (2022). Characterizing Students' 4C Skills Development During Problem-Based Digital Making. *Journal of Science Education and Technology*, *31*(1), 372-385. https://doi.org/10.1007/s10956-022-09961-4

Wiradinata, H., Suryadi, D., & Herman, T. (2023). Students' Mathematical Abstraction Ability in solving Number Pattern Problems Through Discovery Learning. *Journal of Educational Sciences*, 7(1), 84–94. https://doi.org/10.31258/jes.7.1.p.84-94

Zuliyanti, I., Winarti, E. R., Permatasari, G. A. (2023). Mathematical Critical Thinking Ability Viewed from Students' Habits of Mind in Problem Based Learning Assisted Sevima Edlink. *Unnes Journal of Mathematics Education*, *12*(3), 262-269. https://doi.org/10.15294/ujme.v12i3.78957

AUTHOR'S BIOGRAPHY

Shafira Meiria Rahmasari, M.Mat.

Born in Cirebon on May 18, 1998. A lecturer in the Mathematics Education Program at STAI Al-Bahjah Cirebon. Currently pursuing a Doctoral degree in Mathematics Education at Universitas Negeri Semarang. Completed a Bachelor's degree (S1) and Master's degree (S2) in Mathematics at Universitas Diponegoro Semarang.

Prof. Dr. Zaenuri, M.Si., Akt.

Born on December 23, 1964. A lecturer in the Mathematics Education Program at Universitas Negeri Semarang.

Dr. Iwan Junaedi, M.Pd.

Born on March 28, 1971. A lecturer in the Mathematics Education Program at Universitas Negeri Semarang.

Dr. rer.nat. Adi Nur Cahyono, M.Pd.

Born on March 11, 1982. A lecturer in the Mathematics Education Program at Universitas Negeri Semarang.