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Profile of Students' Mathematical Critical Thinking Ability in Solving Flat Sides Geometry Problems

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Abstract: Mathematical critical thinking is an important ability in learning mathematics. In fact, students' mathematical critical thinking ability still low. The purpose of this study to analyze students' mathematical critical thinking ability in the flat sided spaces material. This type of research is a descriptive qualitative, with subject students of class IX MTs Miftahuddin. The instruments are tests of mathematical critical thinking ability and interview guidelines. The test to determine students' mathematical critical thinking skills and interview guidelines to deepen the analysis. The result is each student can meet different indicators. Overall, the average mathematical critical thinking ability of MTs Miftahuddin students in solving flat sided space material is high. Because students understand the material well and use to solving questions in the form of word problems. Indirectly, students have carried to indicators of mathematical critical thinking ability.

Keywords: profile of critical thinking ability, flat side space.

Abstrak: *Berpikir kritis matematis merupakan kemampuan penting dalam mempelajari matematika. Faktanya, kemampuan berpikir kritis matematis siswa masih rendah. Tujuan penelitian ini adalah menganalisis kemampuan berpikir kritis matematis siswa pada materi Bangun Ruang Sisi Datar. Jenis penelitian ini merupakan penelitian kualitatif deskriptif dengan subjek siswa MTs Miftahuddin kelas IX. Adapun instrumen yang digunkan yaitu tes kemampuan berpikir kritis matematis dan pedoman wawancara. Tujuan dilakukannya tes untuk mengetahui kemampuan berpikir kritis matematis siswa dan pedoman wawancara untuk memperdalam hasil analisis. Hasilnya adalah setiap siswa dapat memenuhi indikator yang berbeda-beda. Secara keseluruhan, rata-rata kemampuan berpikir kritis matematis siswa MTs Miftahuddin dalam menyelesaikan soal materi bangun ruang sisi datar tergolong tinggi. Karena siswa menguasai materi dengan baik dan terbiasa menyelesaikan soal berbentuk soal cerita sehingga secara tidak langsung, sisiwa telah melakukan kegiatan yang mengarah kepada indikator-indikator kemampuan berpikir kritis matematis.*

Kata kunci: *profil kemampuan berpikir kritis matematis, bangun ruang sisi datar.*

▪ INTRODUCTION

Mathematical critical thinking is an important ability for students in learning mathematics. Because this ability is a thought process that leads to a conclusion of what to believe and decide what action to take (Utari Sumarmo, Wahyu Hidayat, Rafiq Zulkarnaen, Hamidah Hamidah, 2012). The 21st century also provides challenges for students, one of the challenges is requiring students to have the ability to think critically mathematically. Therefore, many studies are focused on this ability.

This ability requires students to explore various phenomena and situations, questions or a problem to form hypotheses and conclusions, combining all the information obtained and considered true (Syahbana, 2012). Mathematical critical

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thinking skills also provide opportunities for students to analyze problems well, think systematically, communicate arguments, and make the right decisions (Wicaksono, Sagita, & Nugroho, 2017). That is, the ability to think critically mathematically is one of the disciplines that rely on thinking processes so that students really need it in learning mathematics.

In reality, students' mathematical critical thinking skills still tend to be low. Several studies that support this include: research by Jannah & Budiman (2022); (Anggraini, Siagian, & Agustinsa, 2022); Anita & Firmansyah (2022); (Khulsum, Suryaningsih, & Riajanto, 2018) which shows the results that only a few students can fulfill all indicators of critical thinking skills. While most students are unable to fulfill all indicators. This can happen because students still cannot solve problems from non-routine questions. Another cause is that many students face difficulties when given problems that require critical thinking skills, because students have not been trained in solving problems that require critical thinking skills. Based on the previous explanation, it appears that students still have difficulties in analyzing questions, answers, arguments, and the truth of a settlement procedure. (Fatmawati, Mardiyana, & Triyanto, 2014). Therefore, various efforts are needed such as identifying students' critical thinking skills so as to provide an overview to the teacher how and what must be done to improve this ability.

According to experts, mathematical critical thinking consists of several indicators. Widyatiningtyas et al. (2015) used indicators: (1) Finding relationships, (2) Analyzing data, (3) Analyzing elements, (4) Analyzing relationships, (5) Criticizing evidence, and (6) Solving problems. Prayitno et al., (2021) uses indicators: (1) Focus on a question; (2) Can consider the truth of a source; (3) Observation and judgment; (4) Induction; (5) Determine what to do. Agustiana & Imami (2021) uses indicators based on Ennis namely, Inference, Reason, Situation, Overview. Meanwhile, (Anggraini et al., 2022) adopts indicators from (Seventika, Sukestiyarno, & Mariani, 2018), namely (1) interpreting, this indicator provides an illustration that students can write down what items are known and determine the questions intended in the problem. ; 2) analyzing, this indicator provides an overview of students being able to identify relationships between statements, between questions, and between concepts given in the questions by making a mathematical model; 3) evaluating, this indicator provides an overview of students being able to use the correct strategy to solve problems, including doing calculations; 4) making inferences, this indicator provides an overview of students being able to draw conclusions from interpretation activities to evaluations that have been carried out. From these several opinions, the researcher determines the indicators of the adopted Facione (Anggraini et al., 2022). This is because these four indicators can be found in story questions, one of which is in the material for flat sided spaces.

One of the branches of geometry that is studied in class VIII is the material of plane side shapes. Meanwhile, the basic material for flat-sided shapes has been given at the elementary school level. This material is quite essential in everyday life, for example in applying the surface area and volume of a shape. For example, to wrap a gift of a certain size we need to calculate the surface area of the object (gift) so we can determine how many sheets of wrapping paper are needed. Safrina, Ikhsan, & Ahmad, (2014) stated that students must understand geometry because this material can abstractly connect a physical form in the real world with mathematical concepts. In

other words, geometry is a mathematical material that visualizes concrete forms of real objects to become more abstract. Research (Tahir, Nur, Halim, & Zhaahir, 2022) states that in learning mathematics, geometry is material that is considered difficult. One of the geometry materials is a flat side shape. In solving geometric problems which are generally abstract in nature, students are required to be able to think critically.

Based on this explanation, it is important to analyze the profile of each student's mathematical critical thinking skills in solving math problems. By understanding these abilities, it can give the teacher an idea of how best to provide an understanding of the material so that students' mathematical critical thinking skills can increase, especially in the material of flat-sided shapes.

▪ METHOD

This research is qualitative research. While the method used is descriptive. This research was conducted at MTs Miftahuddin in the odd semester of the 2022-2023 school year. Because class VIII had not yet studied this material, class IX was assigned as the research subject. The procedure for this research is: 1) determine valid questions as test instruments adopted from Putri (2019), 2) prepare interview guidelines, 3) conduct tests, 4) record test scores and then group students, 5) take one representative groups of high, medium, and low critical thinking abilities based on the teacher's consideration to be used as research subjects, 6) conducting interviews with selected subjects, 7) analyzing the results of tests and interviews, 8) describing critical thinking skills based on categories.

Student data that has been analyzed based on indicators of students' mathematical critical thinking skills are categorized into 3 categories modified from Nurmaliza, Ariawan, Dahlia, Nufus, & Nurdin (2022). For a percentage value of more than or equal to 71 it is categorized as high. For a percentage value of more than or equal to 61 to less than 71 it is categorized as moderate. Meanwhile, the percentage value less than 61 is categorized as low. The research instrument was in the form of a test sheet containing 4 description questions and interview guidelines. The purpose of the test is to obtain data on each student's mathematical critical thinking skills for later analysis. While interviews were conducted to deepen the results of the analysis.

▪ RESULT AND DISSCUSSION

The test results of 23 students in completing 4 questions related to the flat sided geometric material which contained the four indicators of mathematical critical thinking ability varied widely. Then students are grouped into three categories. The results of the grouping of the 23 students were: in the category of high mathematical critical thinking ability there were 16 students with 2 students achieving a maximum score of 100, while in the medium category there were only 3 students, while in the low category there were only 4 students with 1 student obtaining a score the lowest is 33. So there are more students in the high category than the number of students in the medium and low categories. However, the class average showed a score of 77. So that overall students' critical thinking skills were high. Then, the achievement results of each indicator for each question can be seen in Figure 1.

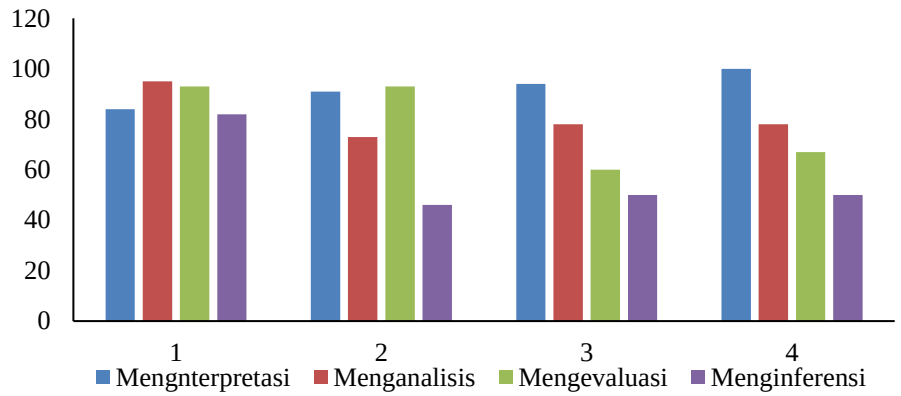

Figure 1. Students' scores on each question per indicator.

Based on Figure 1, the achievement of interpreting indicators is included in the very high category. This means, that 92% of students can determine the information that is known. In addition, students can also determine what problems are asked in the questions. Research by Dores, Wibowo, & Susanti (2020) gave the same result that the achievement of the highest indicators was in writing down the known items and writing down the problems asked in the questions. In analyzing indicators, as many as 81% of students are able to analyze a problem. That is, students can model the problem in a mathematical form, determine the flat side shape formula that will be used to solve the problem. The percentage shows that the achievement of the indicators of student analysis is in the high category.

Achievement on the evaluating indicators of the four questions is 78%. This shows that the evaluation indicator has a high category. While the achievement on the inferring indicator of the four questions is 57% which indicates that the inference indicator has a low category.

It can be seen that the achievement of inferring indicators is the lowest compared to other indicators. Meanwhile, research by Amini, Maimunah, & Roza (2019) shows that student achievement on evaluation indicators is lower than other indicators. Such differences can occur, because each group of students has a different tendency in completing each indicator. The low ability of students on inferring indicators shows that students cannot write conclusions from a result they find. However, the average achievement of each indicator has reached 77%. So that overall, the average students' mathematical critical thinking ability is high.

Based on the scores obtained by the students, the subjects to be used were determined, namely four students. To determine the research subject, the researcher asked for information from the teacher to consider the right subject. The criteria chosen were being able to express opinions properly to collect data through interviews related to the results of the tests that had been carried out. Based on the test results and the teacher's considerations, four students were selected for this research: 2 students in the category of high mathematical critical thinking, namely T-1 students and T-2 students, 1 student in the medium category, namely S-1 students, and 1 student in the category low, namely Student R-1. Furthermore, the profile of students' mathematical critical thinking abilities for each category is presented as follows:

High Mathematical Critical Thinking Ability

T-1 students are able to achieve interpreting indicators on questions number 1 to 4, namely identifying items that are known in the problem, and writing them down without missing any item. Then T-1 students can also write down the problems that become problems in the questions. Such research (Azizah, Sulianto, & Cintang, 2018) found the same thing that students in the high critical thinking ability category were able to write down all known items or facts and also the questions asked in the questions.

On the indicators of analyzing questions number 1 to 4, Student T-1 is able to model the items that are known in the problem and write a problem into a mathematical model. T-1 students are able to make symbols from the items found in the problem and can determine what formula will be used to find the thing being asked as the subject of the problem. In line with research (Azizah et al., 2018) which shows that analyzing indicators can be fulfilled by students who have high thinking skills. In this category, students can analyze problems very well. In addition, this indicator also directs students to take steps to solve problems to the next indicator, namely evaluating.

In the indicators evaluating questions number 1 to 4, T-1 students are able to use mathematical models to solve the problem in question, perform calculations correctly, and double-check the answers they have obtained. Furthermore, on the indicators of inferring questions number 1 to 4, Student T-1 is able to provide conclusions regarding the results that have been obtained. This means that Student T-1 is able to solve all questions correctly. In accordance with the research of Kempirmase, Ayal, & Ngilawajan (2019), on this indicator students with high mathematical critical thinking skills are able to arrange steps for solving them systematically because they have gone through the stages of interpreting and analyzing properly.

In the same category, T-2 students are also able to fulfill all indicators of critical thinking skills. Starting from interpreting, then analyzing, evaluating, and making inferences just like T-1 students. But only questions number 1 and 3. Meanwhile for number 2, Student T-2 can fulfill all indicators except making inferences. Student T-2 did not write down the conclusions obtained after finding the calculation results he obtained. Meanwhile for number 4, Student T-2 did not complete the counting steps so they did not find the final result of the question asked. In addition, Student T-2 also did not write any conclusions. Figure 2 presents Student T-2's answers to number 4 as follows:

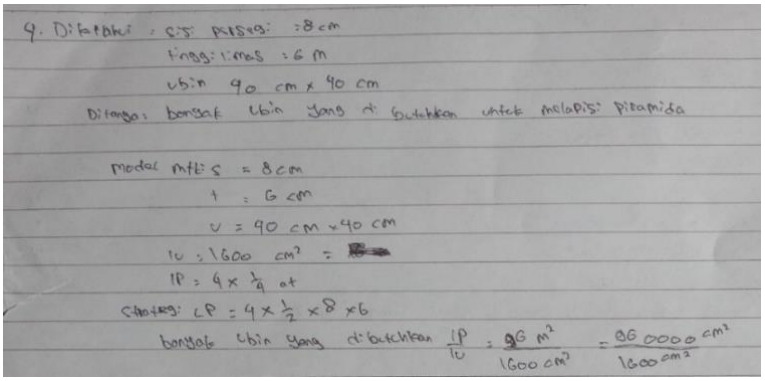

Figure 2. Students' answer t-2 in question number 4

Based on Figure 2, it can be seen that Student T-2 did not complete the step of calculating the number of tiles needed. So that T-2 students cannot get the final results even though the method used is correct. Because they did not find results, Student T-2 also did not write any conclusions. Based on the interview results, Student T-2 forgot to write the conclusion in number 2 because he was not used to writing conclusions. Usually after finding the answer, the problem solving steps are considered to have been completed. Due to running out of time, T-2 students did not have time to complete calculation number 4.1

Moderate Critical Thinking Ability

In questions number 1 to 4, undergraduate students are able to fulfill the interpreting indicator, namely writing down the items that are known in the problem. Furthermore, S-1 students can also determine the problems asked. Based on interviews with S-1 students, to be able to fulfill the interpretation indicators, S-1 students need to read the questions several times to be able to determine the items that are known in the questions completely. In the indicators of analyzing questions number 1 to 4, S-1 students are able to model known items and problems asked in mathematical forms, but in number 4 S-1 students do not write down the known values in the mathematical symbols that have been made.

In the indicators evaluating question number 1 and question number 2, undergraduate students can use a mathematical model to solve the problem in question, do the calculations correctly, and double-check the answers they have obtained. However, for questions number 3 and 4, students could not complete the calculation step, so S-1 students did not find the results of what was asked. The following shows the answers of S-1 students to number 3 in Figure 2:

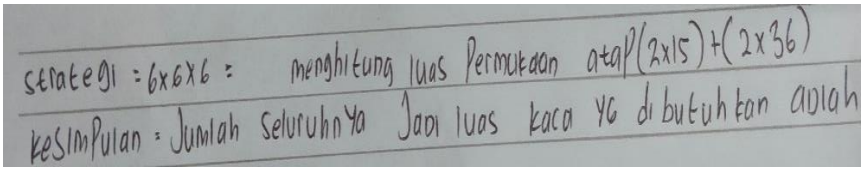

Figure 3. Students' answer s-1 in question number 3

Based on Figure 3, S-1 students did not complete the step of calculating the surface area of a miniature aquarium which is in the shape of a cube while the roof is in the shape of a pyramid. In the inference indicator for questions number 1 to 4, S-1 students did not provide any conclusions regarding the results obtained as shown in Figure 2. Based on interviews, S-1 students could not continue solving numbers 2 and 3 because they did not know the concept of calculating surface area build merged space. He also could not draw conclusions from the results obtained. S-1 students are confused about what to write to give these conclusions. This shows that undergraduate students can fulfill the indicators of interpreting and analyzing the four questions. Fulfilling the indicators of interpreting, analyzing, and evaluating for questions 1 and 2. Fatally, S-1 students cannot fulfill the indicators of inferring on all four questions.

Low Critical Thinking Ability

R-1 students are able to meet the indicators of interpreting questions number 2 and 4. In number 1, R-1 students do not complete writing some of the items contained in the questions. In addition, R-1 students also did not write down the problems asked about. Meanwhile for answer number 3 R-1 students were able to write down all the items known to the question. However, Student R-1 did not write down the problems contained in the questions. Thus, the scores for interpreting indicators for numbers 1 and 3 are not met.

In the analysis indicator at number 1, Student R-1 does not model items in known problems into mathematical forms. In addition, R-1 students also missed writing the problems asked. Meanwhile for numbers 2 to 4 R-1 students are not appropriate in using symbols to model known items. The answers of Student R-1 in fulfilling the analysis indicators are presented in Figure 3 below:

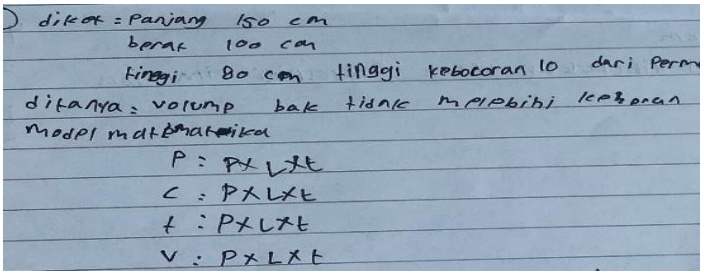

Figure 4. Students' answer r-1 in question number 2

Based on Figure 4, we can see that Student R-1 cannot determine the mathematical model from the known length, width and height of the bathtub. Even though SR-1 can determine the length, width and height of the tub, Student R-1 cannot understand that p is a symbol for length, l is a symbol for width, and t is a symbol for height. This caused Student R-1 not to write down the numbers for each symbol, instead to write down the formula for the volume of a block. But for the formula for the volume of a rectangular tub Student R-1 wrote it down correctly. Based on the interview, R-1 students felt confused about what to model. Usually Student R-1 immediately multiplies the known numbers to determine the volume of the block. However, R-1 students find it difficult to understand questions in the form of stories, even though the meaning is the same, namely asking for the volume of a block.

In evaluating indicators, Student R-1 can use the formula to calculate the volume of the tub, namely problem number 2. However, in problem number 1 Student R-1 does not do any calculations at all, so the score for the evaluating indicator in number 1 is 0. In problem number 3 and question number 4 Student R-1 did not continue the calculation from the formula and method he had written. So that Student R-1 could not find an answer.

In inference indicator, Student R-1 does not provide conclusions regarding the results obtained in question number 2. Meanwhile in question number 1, Student R-1 only writes the items that are known, also does not write down the questions asked so that Student R-1 unable to perform the calculations to find the final result. While in numbers 3 and 4, Student R-1 did not complete the calculation and found the final result so that SR-1 could not provide any conclusions.

Overall, Student R-1 has only provided answers that meet the interpreting indicators on 2 of the 4 numbers, but Student R-1's answers cannot meet the other three indicators on each question. Based on the results of the interviews, R-1 students needed to read the questions repeatedly to be able to find information or items that were known and determine the actual problems being asked about. Then, R-1 students also felt confused about how to change the information or items that were known to be in the form of symbols math symbol. This means that R-1 students do not understand the concept of flat sided geometric material. During the test, the R-1 student never asked questions which he did not understand, even though the researcher had given him the opportunity to ask questions. Research (Hidayanti, As'ari, & Tjang Daniel C, 2016) states that students' low mathematical critical thinking skills are caused by many things. Among other things: 1) students do not understand the concept of the material even though the material has been studied, 2) in drawing conclusions, students tend to rush without first analyzing the completion that has been done, 3) students are not used to working on math problems that direct students to activities analyze and evaluate.

▪ CONCLUSION

The conclusion of this study is that students in the category of high mathematical critical thinking ability can fulfill all indicators on each question, but some students in this category also do not fulfill one indicator on several questions. In other words, students have fulfilled all four indicators, both interpretation, analysis, evaluation and inference but not on the four questions given. There are different indicators that cannot be fulfilled in every question. Students in the moderate category are able to fulfill the indicators of interpreting on each question, fulfilling the indicators of analyzing and evaluating on several questions, and cannot fulfill the indicators of inferring on each question. While students in the low category can only fulfill one indicator, namely interpretation. While other indicators cannot be fulfilled in every question.

Students in each category are able to meet certain indicators and do not meet certain indicators as well. That is, there are different indicators that can be met in each question. Research (Hidayanto, Tedjo, Cahyowati, & Ummah, 2022) also shows the same thing. Each student in each category can meet different indicators. Of the 23 students who took the test, 16 students belonged to the category of high critical thinking skills, 3 students to the medium category and 4 students to the low category. Overall, students have high mathematical critical thinking skills in the material of flat sides. This happens because students are used to working on questions in the form of word problems, so students are used to mentioning known and asked information, modeling questions into mathematical models, using strategies in calculating and drawing conclusions.

▪ REFERENCES

Agustiana, E., & Imami, A. I. (2021). Analisis kemampuan berpikir kritis matematis siswa smp pada materi bangun ruang sisi datar [*Analysis of Junior High School Students' Mathematical Critical Thinking Ability on Flat Sided Space Material*]. *Jurnal Pembelajaran Matematika Inovatif*, *4*(2), 373–382.

Amini, N. U., Maimunah, & Roza, Y. (2019). Analysis student’s critical thinking skills in solving problems in terms of cognitive style. *Jurnal Matematika Dan*

Pembelajaran, *7*(2), 51–69.

Anggraini, N. P., Siagian, T. A., & Agustinsa, R. (2022). Analisis kemampuan berpikir kritis matematis siswa dalam menyelesaikan soal akm [analysis of students' mathematical critical thinking ability in solving minimum competency assessment questions]. *ALGORITMA: Journal of Mathematics Education (AJME)*, *4*(1), 58–78.

Anita, & Firmansyah, D. (2022). analisis kemampuan berpikir kritis matematis siswa sma pada materi barisan aritmatika [analysis of senior high school students' mathematical critical thinking ability on arithmetic sequences material]. *Jurnal Matematika Ilmiah 8*(1), 30–44.

Asysyifa, D. S., Wilujeng, İ., & Kuswanto, H. (2019). Analysis of students critical thinking skills using partial credit models (Pcm) in physics learning. *International Journal of Educational Research Review*, *4*(2), 245-253.

Azizah, M., Sulianto, J., & Cintang, N. (2018). Analsis berpikir kritis siswa sekolah dasar pada pembelajaran matematika kurikulum 2013 [analysis of critical thinking of elementary school students in learning mathematics in the 2013 curriculum]. DoubleClick : *Jurnal Penelitian Pendidikan*, *35*(1), 61–70.

Chikiwa, C., & Schäfer, M. (2018). Promoting critical thinking in multilingual mathematics classes through questioning. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(8), em1562.

Chusni, M. M., Saputro, S., Suranto, S., & Rahardjo, S. B. (2022). Empowering critical thinking skills on different academic levels through discovery-based multiple representation learning. *Jurnal Cakrawala Pendidikan*, *41*(2).

Dores, O. J., Wibowo, D. C., & Susanti, S. (2020). Analisis kemampuan berpikir kritis siswa pada mata pelajaran matematika [analysis of students' critical thinking ability in mathematics]. *J-PiMat : Jurnal Pendidikan Matematika*, *2*(2), 242–254.

Duran, M., & Dökme, I. (2016). The effect of the inquiry-based learning approach on student's critical-thinking skills. *Eurasia Journal of Mathematics Science and Technology Education*, *12*(12).

Evendi, E., Kusaeri, A., Kusaeri, A., Pardi, M., Sucipto, L., Bayani, F., & Prayogi, S. (2022). Assessing students' critical thinking skills viewed from cognitive style: study on implementation of problem-based e-learning model in mathematics courses. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(7).

Fatmawati, H., Mardiyana, & Triyanto. (2014). Analisis berpikir kritis siswa dalam pemecahan masalah matematika berdasarkan polya pada pokok bahasan persamaan kuadrat [analysis of students' critical thinking in solving mathematical problems based on polya on the subject of quadratic equations]. *Jurnal Elektronik Pembelajaran Matematika*, *2*(9), 911–922.

Farah, N., & Ayoubi, Z. (2020). Enhancing the critical thinking skills of grade 8 chemistry students using an inquiry and reflection teaching method. *Journal of Education in Science Environment and Health*, *6*(3), 207-219.

Gayazov, A. S., Zamaletdinova, G. F., Amirov, A. F., Kostryukov, A. V., & Tikhomirova, E. I. (2016). Modern teaching tendencies of critical thinking forming of university students. *International Review of Management and Marketing*, *6*(2), 358-363.

Gómez, R. L., & Suárez, A. M. (2020). Do inquiry-based teaching and school climate influence science achievement and critical thinking? Evidence from PISA 2015. *International Journal of STEM Education*, *7*(1), 1-11.

Hidayanti, D., As'ari, A. R., & Tjang Daniel C. (2016). Analisis kemampuan berpikir kritis siswa smp kelas ix pada materi kesebangunan [analysis of critical thinking ability of grade ix junior school students on congruence material]. DoubleClick : *PROSIDING : Konferensi Nasional Penelitian Matematika Dan Pembelajaran (KNPMP I)*, 276–285.

Hidayanto, E., Tedjo, E., Cahyowati, D., & Ummah, A. H. (2022). Students' critical thinking disposition in working on numeration problems. *Jurnal Pendidikan MIPA*, *23*(3), 1224–1240.

Jannah, M., & Budiman, I. (2022). Analisis kemampuan berpikir kritis matematis siswa dalam menyelesaikan soal cerita pada materi lingkaran [analysis of students' mathematical critical thinking ability in solving story problems on circle material]. *Jurnal Pembelajaran Inovatif (JPMI) 5*(1), 237–246.

Kempirmase, F., Ayal, C. S., & Ngilawajan, D. A. (2019). Kemampuan berpikir kritis siswa dalam menyelesaikan soal-soal higher order thinking skill (hots) pada materi barisan dan deret aritmatika di kelas xi sma negeri 10 ambon [students' critical thinking ability in solving higher order thinking skill (hots) questions on arithmetic sequences and series material in class xi sma negeri 10 ambon]. DoubleClick : *Prosiding Seminar Nasional Pendidikan Matematika Universitas Pattimura*, *1*, 21–24.

Khulsum, R., Suryaningsih, Y., & Riajanto, M. L. E. J. (2018). Analisis kemampuan berpikir kritis matematis (bkm) siswa smp pada materi segiempat dan segitiga [analysis of mathematical critical thinking ability (bkm) of junior high school students on quadrilaterals and triangles]. *Jurnal Pembelajaran Inovatif (JPMI)*, *1*(5), 1015–1024.

Kurniati, K., Kusumah, Y. S., Sabandar, J., & Herman, T. (2015). Mathematical critical thinking ability through contextual teaching and learning approach. *Journal on Mathematics Education*, *6*(1), 53-62.

Lin, S., Hu, H. C., & Chiu, C. K. (2020). Training practices of self-efficacy on critical thinking skills and literacy: importance-performance matrix analysis. *EURASIA Journal of Mathematics, Science and Technology Education*, *16*(1).

Mafarja, N., Zulnaidi, H., & Fadzil, H. M. (2022). Using reciprocal teaching strategy to improve physics students' critical thinking ability. *EURASIA Journal of Mathematics, Science and Technology Education*, *18*(1), em2069.

Marthaliakirana, A. D., Suwono, H., Saefi, M., & Gofur, A. (2022). Problem-based learning with metacognitive prompts for enhancing argumentation and critical thinking of secondary school students. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(9), em2148.

Muhibbuddin, M., Sari, T. N., & Khairil, K. (2020). The application of group investigation model in circulation learning system to improve students'science process skills and critical thinking abilities. *IJAEDU-International E-Journal of Advances in Education*, *6*(17), 178-183.

Munawaroh, H. (2018). international journal of educational methodology teachers 'perceptions of innovative learning model toward critical thinking ability.

International Journal of Educational Methodology, *4*(3), 153-160.

Narmaditya, B. S., Wulandari, D., & Sakarji, S. R. B. (2018). Does problem-based learning improve critical thinking skill?. *Jurnal Cakrawala Pendidikan*, *37*(3).

Nurmaliza, Ariawan, R., Dahlia, A., Nufus, H., & Nurdin, E. (2022). Analysis of mathematical critical thinking ability viewed from habits of mind. *Jurnal Pendidikan MIPA*, *20*(3), 904–917.

Özyurt, Ö. (2015). Examining the critical thinking dispositions and the problem solving skills of computer engineering students. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(2), 353-361.

Prayitno, S. H., Ladyawati, E., & Fiantika, F. R. (2021). Profil kemampuan berpikir kritis siswa smp dengan model pembelajaran jucama dintinjau dari gender [profile of critical thinking ability of junior high school students with the jucama learning model in view of gender]. *Wahana Tridarma Perguruan Tinggi*, *73*(2), 149–165.

Putri, A. (2019). pengembangan perangkat pembelajaran matematika dengan model discovery learning untuk meningkatkan kemampuan berpikir kritis matematis pada materi bangun ruang sisi datar peserta didik smp kelas viii [development of mathematical learning devices with the discovery learning model to improve mathematical critical thinking skills in the material of flat sided spaces for class viii junior high school students]. *Magister Mathematics Education, University of Riau.*

Reynders, G., Lantz, J., Ruder, S. M., Stanford, C. L., & Cole, R. S. (2020). Rubrics to assess critical thinking and information processing in undergraduate STEM courses. *International Journal of STEM Education*, *7*(1), 1-15.

Safrina, K., Ikhsan, M., & Ahmad, A. (2014). Peningkatan Kemampuan Pemecahan Masalah Geometri melalui Pembelajaran Kooperatif Berbasis Teori Van Hiele [*Improvement of Geometry Problem Solving Ability through Van Hiele Theory-Based Cooperative Learning*]. *Jurnal Dikdatik Matematika*, *1*(1), 9–20.

Sasi, A. S. (2018). Enhancing critical thinking in malaysian primary school students through pls method. *International Journal of Educational Methodology*, *4*(4), 243-257.

Seventika, S. Y., Sukestiyarno, Y. L., & Mariani, S. (2018). Critical thinking analysis based on Facione (2015) – Angelo (1995) logical mathematics material of vocational high school (VHS) Critical thinking analysis based on Facione (2015) – Angelo (1995) logical mathematics material of vocational high sc. (2015).

Simpson, A. (2010). Integrating technology with literacy: Using teacher-guided collaborative online learning to encourage critical thinking. *ALT-J: Reseach in Learning Technology*, *18*(2), 119-131.

Spector, J. M., & Ma, S. (2019). Inquiry and critical thinking skills for the next generation: from artificial intelligence back to human intelligence. *Smart Learning Environments*, *6*(1), 1-11.

Sumarmo, U., Hidayat, W., Zulkarnaen, R., Hamidah H., & Sariningsih, R. (2012). Kemampuan dan disposisi berpikir logis, kritis, dan kreatif matematik [ability and disposition of mathematical logical, critical, and creative thinking]. DoubleClick : *Jurnal Pengajaran MIPA*, *17*(1), 17–33.

Syahbana, A. (2012). Peningkatan kemampuan berpikir kritis matematis siswa smp melalui pendekatan contextual teaching and learning [improving junior high

school students' mathematical critical thinking skills through a contextual teaching and learning approach]. *Edumatica*, *02*(01), 45–57.

Tahir, S. R., Nur, S., Halim, H., & Zhaahir, M. (2022). analisis kemampuan berpikir kritis matematis dalam menyelesaikan soal bangun datar pada siswa kelas VIIIB MTs [analysis of mathematical critical thinking ability in solving flat shape problems in class VIIIB MTs]. *Mandalika: Mathematics and Education Journal 4*(1), 21–32.

Wicaksono, B., Sagita, L., & Nugroho, W. (2017). Model pembelajaran group investigation (gi) dan think pair share (tps) terhadap kemampuan berpikir kritis [group investigation (gi) and think pair share (tps) learning models on critical thinking ability]. *Aksioma*, *8*(2), 1–8.

Widyatiningtyas, R., Kusumah, Y. S., Sumarmo, U., & Sabandar, J. (2015). The impact of problem based learning approach to senior high school student's mathematics critical thinking ability. *IndoMS-JME*, *6*(2), 30–38.