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Students' Mathematical Critical Thinking Reviewed from Gregorc's Thinking Style in Flipped Classroom Learning Assisted by Google Site

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Abstract

Mathematical critical thinking is essential, especially for students. This study aims to describe students' mathematical critical thinking according to Facione, as reviewed from Gregorc's thinking style in Flipped Classroom learning assisted by Google Site. The research method used is qualitative descriptive. The subjects of this study were students in class X-D SMA Negeri 1 Padamara in Purbalingga who were selected using purposive sampling techniques, namely 2 students from each type of Gregorian thinking style, namely 2 Concrete Sequential (CS) students, 2 Abstract Sequential (AS) students, 2 Abstract Random (AR) students, and 2 Concrete Random (CR) students. The data collection techniques in this study are tests, questionnaires, interviews, observations, and documentation. The data analysis techniques used are data collection, data reduction, data presentation, and conclusion drawing. The results show that in Flipped Classroom learning assisted by Google Site, students' mathematical critical thinking varies based on Gregorc's thinking style. Concrete Sequential (CS) students can do interpretation and inference, not optimal in analysis and evaluation, and need to be explored in explanation. Abstract Sequential (AS) students can do interpretation, evaluation, inference, and explanation well, but they are not optimal in analysis. Abstract Random (AR) students can do interpretation and inference, but not optimally in analysis, evaluation, and explanation. Meanwhile, Concrete Random (CR) students can do interpretation and inference, which is not optimal in analysis, and need to be explored in evaluation and explanation. Flipped Classroom learning assisted by Google Site is expected to be applied in the classroom to help stimulate students' mathematical critical thinking.

1. Introduction

Mathematical critical thinking on the thinking of each individual is essential in the current era, especially for students, as the next generation of the nation. According to Teknowijoyo & Marpelina (2022) the industrial revolution 4.0 and society 5.0 have a close relationship with education in Indonesia, this era emphasizes the ability to develop creativity and critical thinking, a way of thinking that needs to be understood and used, namely analytical, critical, and creative to be able to adapt to the times. In this era of the industrial revolution 4.0, modern technology has a great influence in all areas of life to be able to face the demands of life in the field of education, honing critical thinking skills in mathematics is essential (Agustina, 2019). Mathematical critical thinking can be a force to face and compete in this era, especially in education. Mathematical critical thinking makes individuals able to face the demands of life in modern technological advances in the development of the times. Individuals need to think critically mathematically in keeping with the development of the times, so as not to become human resources that are left behind.

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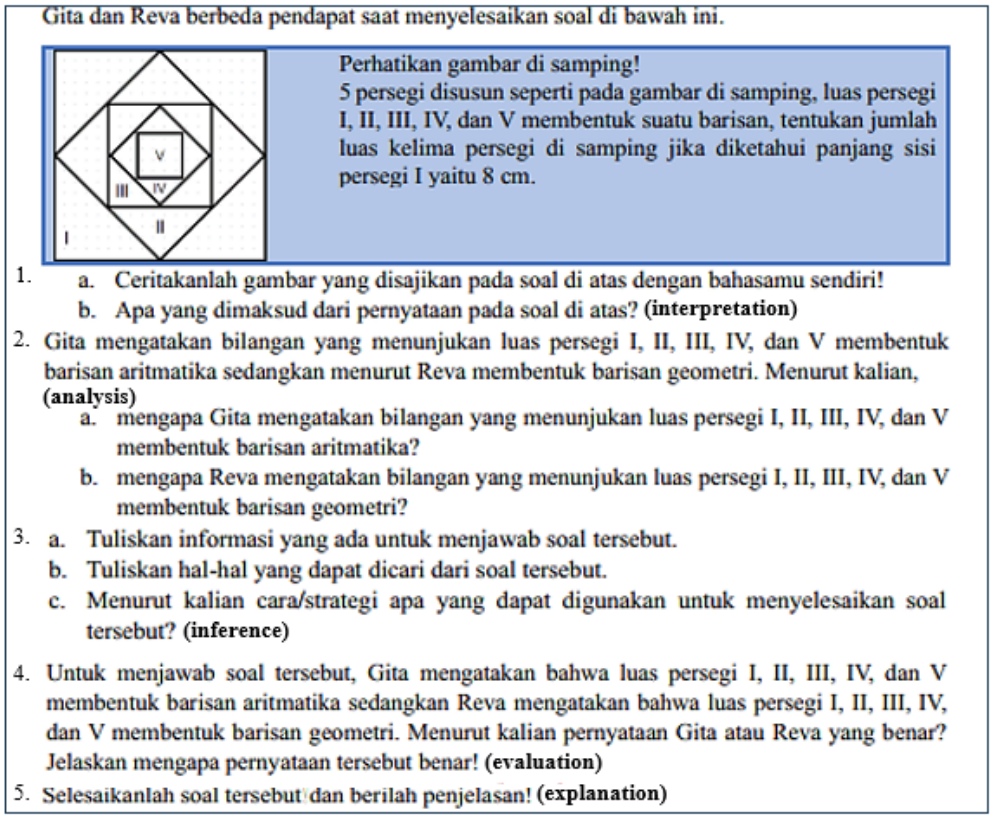
Mathematical critical thinking can help solve a problem in life logically and correctly. Facione (2011) said that critical thinking means thinking well and is the opposite of illogical thinking. In line with that, according to Saputra (2020) critical thinking is more correct in thinking, working, and providing assistance more appropriately when determining the relationship between one thing and another. Problems in life can be solved easily with logical thinking and directed to the truth. In problems that are closely related to mathematics, by thinking critically mathematically, the problem can be solved correctly. It is important for all individuals, including students as the successors of the nation, to have critical thinking, especially in mathematics, to be able to solve problems faced in life.

A preliminary study was conducted at SMAN 1 Padamara on October 14, 2024, on 36 students in grades X-D By conducting a mathematical critical thinking test, we obtained results that most students could not think critically well mathematically. Mathematical critical thinking explored during preliminary studies is a critical thinking skill according to Facione (2011) where a person is said to have skills in critical thinking if they can to interpretation, analyze, inference, evaluation, explanation, and self-regulation. Self-regulation is a skill to assess independently with self-awareness of the reasoning that it has, so that in this study it does not explore self-regulation skills because it is adjusted to research that uses students' mathematical critical thinking tests while self-regulation requires long-term observation and more in-depth instruments so that it is not by the limitations of research time. The preliminary study questions tested can be seen in Figure 1 below.


Gita dan Reva berbeda pendapat saat menyelesaikan soal di bawah ini.

Perhatikan gambar di samping!
5 persegi disusun seperti pada gambar di samping, luas persegi I, II, III, IV, dan V membentuk suatu barisan, tentukan jumlah luas kelima persegi di samping jika diketahui panjang sisi persegi I yaitu 8 cm.

1. a. Ceritakanlah gambar yang disajikan pada soal di atas dengan bahasamu sendiri!
   b. Apa yang dimaksud dari pernyataan pada soal di atas? **(interpretation)**
2. Gita mengatakan bilangan yang menunjukan luas persegi I, II, III, IV, dan V membentuk barisan aritmatika sedangkan menurut Reva membentuk barisan geometri. Menurut kalian, **(analysis)**
   a. mengapa Gita mengatakan bilangan yang menunjukan luas persegi I, II, III, IV, dan V membentuk barisan aritmatika?
   b. mengapa Reva mengatakan bilangan yang menunjukan luas persegi I, II, III, IV, dan V membentuk barisan geometri?
3. a. Tuliskan informasi yang ada untuk menjawab soal tersebut.
   b. Tuliskan hal-hal yang dapat dicari dari soal tersebut.
   c. Menurut kalian cara/strategi apa yang dapat digunakan untuk menyelesaikan soal tersebut? **(inference)**
4. Untuk menjawab soal tersebut, Gita mengatakan bahwa luas persegi I, II, III, IV, dan V membentuk barisan aritmatika sedangkan Reva mengatakan bahwa luas persegi I, II, III, IV, dan V membentuk barisan geometri. Menurut kalian pernyataan Gita atau Reva yang benar? Jelaskan mengapa pernyataan tersebut benar! **(evaluation)**
5. Selesaikanlah soal tersebut dan berilah penjelasan! **(explanation)**

Figure 1. Introductory Study Questions for Mathematical Critical Thinking

The problem in Figure 1 is about the different opinions between two people in solving row and series problems. The question contains a picture of the squares that are arranged and only the side of one of the existing squares is known, the number that expresses the area of the squares in sequence forming a row of geometric arithmetic, students are asked to find the number of areas of these squares with the concept of rows and series of arithmetic and geometry. To solve this problem with mathematical critical thinking, students need to interpret, analyze, inference, evaluate, and explain the problems presented.

The results of the preliminary study at SMAN 1 Padamara by a mathematical critical thinking test of students, stated that most of the students (32 students) in class X-D were able to interpret, none of the students did the analysis correctly, only 6 students made an inference correctly, only 8 students were able

to evaluate correctly, and there were no students who did the explanation correctly and completely. Here is Figure 2 of the results of the wrong student work in conducting the analysis.

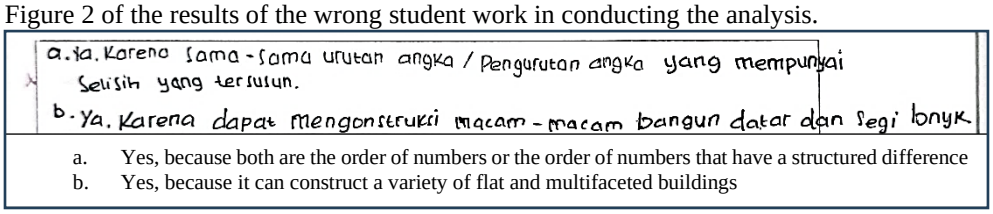


Figure 2. Example of Student Analyze Results

Based on Figure 2, the student immediately identifies problems with the concepts of arithmetic and geometric rows through understanding alone, without calculating the area of each square first. Students say numbers that indicate square areas I, II, III, IV, and V form arithmetic rows because they are both sequences of numbers/sequences of numbers that have arranged differences, and students say numbers that indicate Square areas I, II, III, IV, and V form geometric rows because they can construct various flat and rectangular shapes.

Given the importance of mathematical critical thinking in the thinking of each individual, especially students, and the fact that critical thinking has not been developed in students in the preliminary study above, it is necessary to make efforts to stimulate students' mathematical critical thinking. One of the first efforts that can be made is to identify the characteristics of each student, especially in the thinking process, namely when receiving and processing information. This is in line with Setyawan & Rahman (2013) who stated that teachers need to know the differences in students' thinking processes in receiving and processing the information provided, so that it can be a source of information and understanding for students to master knowledge and skills in thinking and teachers get strategies to design learning according to students' thinking processes.

Gregorc's thinking style becomes characteristic in students that can be used to identify students' mathematical critical thinking skills. Gregorc's thinking style is a mindset that provides characteristics of how individuals can receive and process existing information and then organize it in a certain way (Sutopo & Waluya, 2023). The Gregorc thinking style of different students results in different criteria in solving Higher Order Thinking (HOT) problems (Putri et al., 2022). Higher Order Thinking (HOT) can be described as a composition of three categories: basic thinking, critical thinking, and creative thinking (Crawford & Brown, 2002). Gregorc's different thinking styles in students allow for differences in their mathematical critical thinking. In line with this, Fauzi et al. (2020) stated that there is a relationship between students' mathematical critical thinking and Gregorian thinking style.

Flipped Classroom is one of the learning strategies that has the potential to develop and stimulate students' mathematical critical thinking. Self-paced learning in the Flipped Classroom requires students to receive and process information about the material being studied by understanding the meaning and summarizing it on their own. According to Wei et al. (2020) summarizing while watching videos is an important exercise in Flipped Classroom learning; notes consist of four parts, namely title, important content, questions, and summary. According to Nuraida (2019) various ways that can stimulate students' critical thinking one of which is by summarizing, because students are required to draw the meaning of the writing so that they can conclude the writing. Based on this, activities in independent learning in Flipped Classroom learning have the potential to stimulate students' critical thinking in interpretation. Classroom learning in Flipped Classroom provides maximum time to deepen understanding, discuss, solve a problem, and solve problems in a directed manner. According to Sholikhah & Syah (2022) with discussion, students are required to analyze information, consider different perspectives, and conclude with logic. Based on this, discussion activities in classroom learning stimulate students' mathematical critical thinking in analysis, evaluation, and inference. In addition, activities in solving a problem train students in stating the results of solving existing problems. So that these activities stimulate students' mathematical critical thinking in explanation.

Flipped Classroom learning needs to be implemented with the help of the media. The right media for Flipped Classroom learning is a medium that can be used for independent learning at home and classroom learning. Google Sites is one of the platforms that can be used for Flipped Classroom learning media. Google Sites is an example of technology-based media, namely in the form of a web that can be accessed by students everywhere with an internet connection. This is with Flipped Classroom learning that is carried

out at home and in the classroom. According to Nugraha et al. (2023) Flipped Classroom learning with the help of Google Sites can improve student learning achievement. Flipped Classroom with the help of Google Site is proven to increase student activity in learning Waryana (2021).

In addition, Google Sites as a technology-based learning medium has the potential to develop and stimulate students' mathematical critical thinking. Google Sites is a medium that can contain various forms of files, such as images, videos, text, games, and ratings. The presentation of material in the form of images, videos, and text will develop students' critical thinking skills in interpretation. In addition, Google Sites can contain assessments, which are used to develop students' skills in evaluating and explaining. According to Ratnawati et al. (2024) there is a positive impact of Google Site media on students' mathematical critical thinking.

Based on the relationship to the things that have been described above, the formulation of the problem in this study is how the description of students' mathematical critical thinking is reviewed from Gregorc's thinking style in Flipped Classroom learning with the help of Google Sites. This study aims to describe Students' mathematical critical thinking reviewed from Gregorc's thinking style in Flipped Classroom learning, assisted by Google Sites. The results of the research are expected to be able to provide a reference on critical thinking skills when viewed from Gregorc's thinking style in the Flipped Classroom learning model assisted by Google Site, provide learning references to develop and stimulate students' mathematical critical thinking with the Flipped Classroom learning model assisted by Google Site, and become a reference in optimizing the quality of mathematics learning based on information about thinking skills students' mathematical criticism when viewed from Gregorc's thinking style in Flipped Classroom learning with the help of Google Site.

2. Methods

The research method used in this study was a descriptive qualitative method because the research results emphasize more on meaning than generalizations (Sugiyono, 2013), and describe events that are heard, felt, and made in narrative or descriptive statements (Strauss & Corbin, 2013). Descriptive research was conducted to provide a systematic, factual, and accurate description of the facts and characteristics of a particular population. This is according to the opinion of Fathoni (2006). The facts described in the form of descriptions in this study are students' mathematical critical thinking skills, reviewed by Gregorc's thinking style. The qualitative method in this study was used to describe students' mathematical critical thinking, reviewed from Gregorc's thinking style in the Flipped Classroom learning model, assisted by Google Sites. The data collection techniques in this study are tests, questionnaires, interviews, observations, and documentation. The research instruments used were learning tools, mathematical critical thinking tests, Gregorian thinking style questionnaires, interview guidelines, and observation sheets. The data analysis technique used refers to the Miles & Huberman (1984) model, namely data collection, data reduction, data presentation, as well as drawing conclusions and verification, which is an interactive process that takes place and repeats continuously until it is complete, so that the data is saturated.

The location of this research was SMAN 1 Padamara, which is located on JL. Raya Padamara, Sidahurip, Padamara, Purbalingga Regency, Central Java. This research was conducted in class X-D SMAN 1 Padamara. The subjects in this study were students with Concrete Sequential (CS), Abstract Sequential (AS), Abstract Random (AR), and Concrete Random (CR) thinking styles. The research subject consisted of 2 people from each Gregorian thinking style who were selected by purposive sampling technique, which was selected based on the tendency in the categories of CS, AS, AR, and CR thinking styles with additional criteria, namely subjects who were able to represent students' critical thinking skills with the same thinking style, good communication skills, and consistency of students' Gregorc thinking style on the results of the initial and final questionnaires of Gregorc students' thinking styles.

3. Results & Discussions

3.1. Result

Table 1. Results of Gregorc Thinking Style Questionnaire for Students of Grade X-D SMAN 1 Padamara

Gregorc's Thinking Style	Many Students	Percentage
Concrete Sequential (CS)	12	34%
Abstract Sequential (AS)	6	17%
Abstract Random (AR)	12	34%
Concrete Random (CR)	3	9%
Etc.	2	6%
Total	35	100%

Table 2. The Results of Students' Mathematical Critical Thinking Triangulation Reviewed from Gregorc's Thinking Style

	CS						AS						AR						CR					
Subject	S-28			S-31			S-01			S-21			S-12			S-30			S-07			S-14		
No	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Interpretation	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
	C			C			C			C			C			C			C			C		
	Can						Can						Can						Can					
	CS students **can** interpret, with the activity carried out, retell the visualization of the data provided using their own language and from real information.						AS students **can** interpret, the activity carried out is to retell the situation of the questions and visualize the data provided using their own language.						AR students **can** interpret, with the activity carried out, retell the visualization of the data given using their own language.						CR students **can** interpret, with the activities carried out, they seem to be able to see the complete picture by retelling the situation of the problem and visualizing the data given using their own language, but tend to miss some of the moments by sometimes only telling a part of it.					
Analyze	NE	NO	C	NE	NO	C	C	NO	NO	C	NO	NO	NO	NO	NO	NO	NO	NO	NO	C	NO	NO	NO	NO
	NO			NO			NO			NO			NO			NO			NO			NO		
	Not Optimal						Not Optimal						Not Optimal						Not Optimal					
	CS students **have not been optimal** in conducting analysis, with the activities carried out identifying the relationship between problems and concepts, but tend to rely on observation and do not do detailed calculations.						AS students **have not been optimal** in conducting analysis, the activities carried out are to identify the relationship between problems and concepts according to the needs of the questions, namely through calculations/ observations, but it is not appropriate because they are not thorough.						AR students **have not been optimal** in conducting analysis, with the activities carried out being to identify the relationship between the problem and the concept according to the needs of the question, namely through calculation/ observation but it is not appropriate due to misconception and lack of thoroughness and likes to ask other people questions before making decisions.						CR students **have not been optimal** in conducting analysis, with the activities carried out are to identify the relationship between problems and concepts according to the needs of the questions, namely through calculations/ observations but it is not appropriate due to misconceptions and lack of thoroughness.					

Evaluation	NO NE C NO NO NO C NE C C NE C	C NE NO NE NO C	NE NE NO NE NE C	
	NO NO	C C	NO NO	NE NE
	Not Optimal	Can	Not Optimal	Need To Be Explored
	CS students **have not been optimal** in conducting evaluations, with activities carried out to assess the credibility of other statements but tend to give reasons based on estimates.	AS students **can** evaluate the situation, with the activity being carried out to assess the credibility of the statement by giving reasons based on the results of the analysis	AR students **have not been optimal** in conducting evaluations, with the activities carried out are to assess the credibility of other statements correctly but the reasons given are not appropriate.	CR students **need to be explored** in conducting evaluations, with the activities carried out are not to assess the credibility of other statements correctly by giving reasons based on the results of the analysis or the right ones, only judging based on inappropriate concepts.
Inference	C C C C C C C NO C NO C C	C C NO C C C	C NO C C C	C C C C NO C
	C C	C C	C C	C C
	Can	Can	Can	Can
	CS students **can** make inferences, with the activities carried out are to identify the necessary information and draw logical conclusions.	AS students **can** make inferences, with the activities carried out are to identify the necessary information and draw logical conclusions by analyzing	AR students **can** make inferences, with activities that are carried out to identify the necessary information and draw logical conclusions that tend to be realistic.	CR students **can** make inferences, with the activities carried out are to identify the necessary information and draw logical conclusions.
Explanation	NE NE C NE NO NE C NO C C C C	NO NO C NO NE C	NE NE NO NE NE C	
	NE NE	C C	NO NO	NE NE
	Need To Be Explored	Can	Not Optimal	Need To Be Explored
	CS students **need to be explored** in explanations work, with the activities carried out are not stating results and explanations based on evidentiary or conceptual considerations, only stating results incomplete and unconceptual explanations.	AS students **can** explain, with activities carried out to state results and explanations based on consideration of analytical and conceptual evidence.	AR students **have not been optimal** in explanations work, with the activities carried out to provide explanations based on analytical or conceptual results but state the results inappropriately.	CR students **need to be explored** in explanations work, with the activities carried out not stating results and explanations based on evidentiary or conceptual considerations, only stating results inappropriately without providing conceptual explanations and tending to use their own methods.

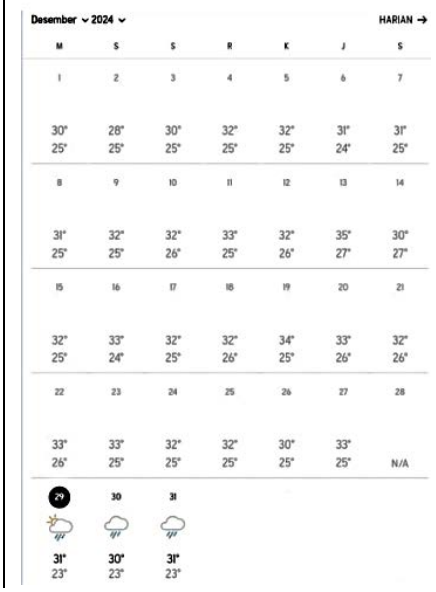
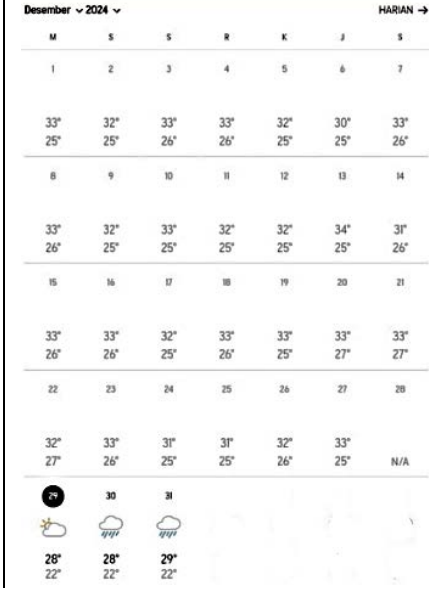
The research subjects were 2 students with a Concrete Sequential (CS) thinking style, 2 students with an Abstract Sequential (AS) thinking style, 2 students with an Abstract Random (AR) thinking style, and 2 students with a Concrete Random (CR) thinking style selected from the student data in Table 1. The research subjects were selected with additional criteria, namely students who could represent the mathematical critical thinking skills of students with the same thinking style, ability to communicate, and the results of consistent thinking style tendencies when filling out the initial and final thinking style questionnaires.

Based on the results of the thinking style test, students' data is grouped according to their thinking style. Then, an analysis of student work results was carried out with the criteria for scoring critical thinking tests. Subject triangulation was carried out by all students in grades X-D to the results of the mathematical critical thinking test. Then, students who meet the criteria are selected, namely S-28 and S-31 as the subjects of CS, S-01 and S-21 students as the subjects of AS, S-12 and S-30 students as the subjects of AR, S-07 and S-14 students as the subjects of CR.

The selected research subjects were described as mathematically critical thinking. The triangulation of techniques and subjects was carried out based on the results of mathematical critical thinking tests and subject interviews of 3 critical thinking questions, each of which consisted of questions for interpretation, analysis, evaluation, inference, and explanation skills. The results of the triangulation of students' mathematical critical thinking are reviewed from Gregorc's thinking style presented in Table 2.

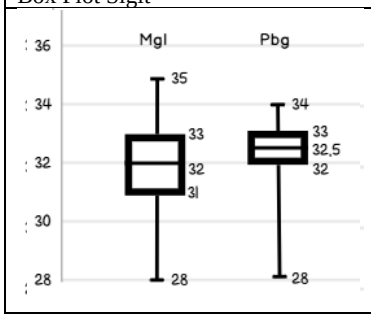
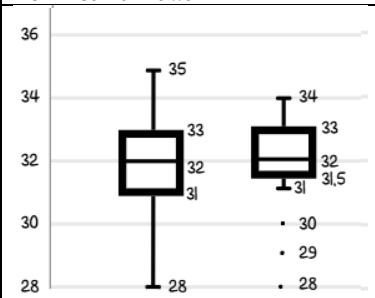
Based on Table 2, due to the limited number of pages, only a few subjects were taken to be described in detail related to their mathematical critical thinking. The questions used are question no.2 with interpretation questions in part (a), analysis in part (b), evaluation in part (c), inference in part (d), and explanation in part (e), Figure 3 is question no 2.

Sigit dan Kurniawan berencana untuk liburan akhir tahun antara pergi berlibur ke Magelang atau Purbalingga, namun sebelumnya mereka ingin membandingkan prakiraan suhu yang ada di Magelang dan di Purbalingga untuk memutuskan tujuan daerah liburannya. Mereka ingin berlibur di daerah yang memiliki suhu tidak begitu bervariasi berdasarkan suhu tertinggi hariannya. Berikut merupakan kumpulan data prakiraan suhu di Magelang dan Purbalingga pada bulan Desember 2024 yang diambil dari AccuWeather.

Magelang	Purbalingga
	

(baris atas = suhu tertinggi, baris bawah = suhu terendah)

a. Ceritakanlah pernyataan dan kumpulan data di atas menggunakan bahasamu sendiri! **(interpretation**
b. Berdasarkan data tersebut, bagaimana variasi suhu berdasarkan suhu tertinggi harian di Magelang dan Purbalingga? sertakan alasan yang mendukung. **(analysis)**
c. Sigit dan Kurniawan membuat box plot untuk membandingan suhu kedua kabupaten berdasarkan suhu tertinggi hariannya, berikut hasilnya.

Box Plot Sigit	Box Plot Kurniawan
	

Mereka berdua memiliki hasil gambar box plot yang berbeda, menurutmu manakah yang benar dan salah diantara mereka? Mengapa benar dan mengapa salah? jika keduanya tidak benar berikan hasilmu sendiri. **(evaluation)**

d. Kesimpulan apa yang dapat diambil dari rencana liburan Sigit dan Kurniawan? **(inference)**
e. Menurut kalian 25% data di bulan Desember di Magelang dan Purbalingga memiliki suhu tinggi yang lebih hangat dari berapa ℃? Jelaskan! **(explanation)**

Figure 3. Mathematical Critical Thinking Questions no 2

3.1.1. Description of Mathematical Critical Thinking of CS Student

In question no. 2b, subject S-31 **has not been optimal** in conducting the **analysis**. This is shown by the results of the work in Figure 4 below.

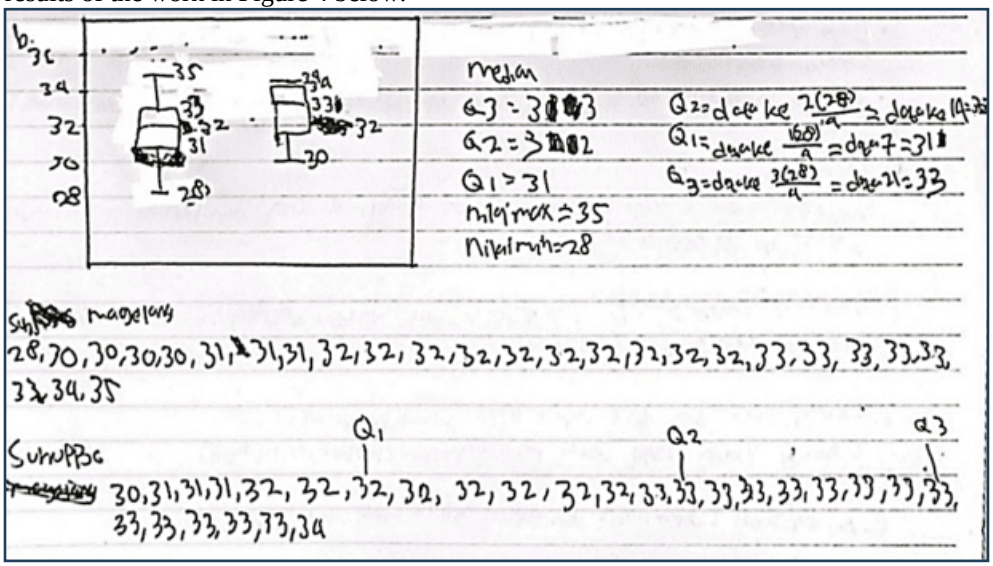


Figure 4. Work Results S-31 no 2b

Based on Figure 4, in analyzing question number 2b, it is necessary to identify the relationship between the problem and the concept through calculations, the subject identifies the relationship between the problem and the concept (box plot) and not through detailed calculations (Q1, Q2, Q3, minus value, the max value is not correct). Subjects appear to be less skilled at identifying the relationship between problems and concepts to express information. Subjects used box plots to analyze temperature variations but did not perform detailed calculations so that the results obtained were not precise.

Based on the interview excerpts, the subject of S-31 **has not been optimal** in conducting the analysis. Excerpts of the researcher's interview with subject S-31 related to analysis skills in question no 2b are as follows.

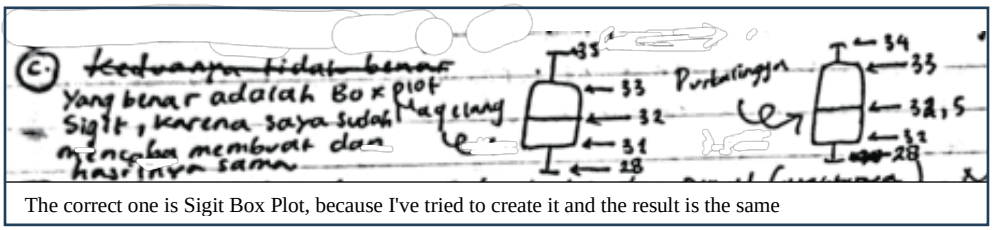
P : *How do you know the temperature variations in Magelang and Purbalingga? From the results of your work, you draw your own box plot but do not say how the temperature varies*
S-31 : *The temperature in Purbalingga is more stable, because there are more 33 degrees, the same data is more stable*
P : *But do you know that the temperature variation can be seen from the width of the box plot/IQR box, or it can also be with the range*
S-31 : *Yes, I know, it was explained at that time*
P : *Then what is this based on?*
S-31 : *Yes, based on the width of the box plot as well, Magleang is wider so it is more varied than Purbalingga*

Based on the interview excerpts, the subjects identify the relationship between the problem and the concept (box plot) and tend to rely on observation. The results of the interviews showed that the S-31 subjects were less skilled in identifying the relationship between problems and concepts to express information through active analysis, i.e. calculations. Subjects identify with box plots but tend to rely on observations that the same temperature data is more so they think the data is more stable.

Based on the triangulation of techniques (test results and interview results), it can be concluded that the subject of S-31 **has not been optimal** in conducting analysis on question no. 2b. Subjects conduct analysis by identifying the relationship between problems and concepts, and not through detailed calculations and tend to rely on observation.

3.1.2. Description of Mathematical Critical Thinking of AS Student

In question no. 2c, subject S-21 **needs to be explored** in conducting the **evaluation**. This is shown by the results of the work in Figure 5 below.



The correct one is Sigit Box Plot, because I've tried to create it and the result is the same

Figure 5. Work Results S-21 no 2c

Based on Figure 5, the subject does not properly assess the credibility of other statements by giving a proper reason (based on the results of the analysis/concept), but only based on the results of the analysis, which is not detailed, so the analysis is incorrect. The subject appears to be unskilled in assessing the credibility of other statements. The subject gave a reason based on the conformity of the self-made image, but the subject did an undetailed analysis by not counting the outliers that should be in the box plot, so that the judgment given was wrong because there should not have been a correct box plot.

Based on the interview excerpts, the subject of S-21 **needs to be explored** in conducting an evaluation. Excerpts of the researcher's interview with subject S-21 related to evaluation skills in question no. 2c are as follows.

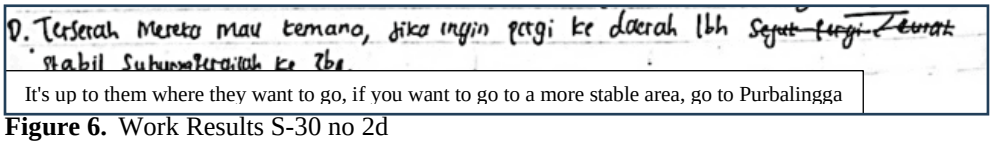
P : *In the statement about no 2c, you think the correct one is Sigit's box plot, why?*
S-21 : *Because at the time of the work, I tried to redraw the box plot, and the box plot I drew was more similar to Sigit's box plot, almost the same*
P : *For no 2c, there is no correct box plot because after calculating the data, there are outliers. What kind of outliers in the box plot are drawn? You know what?*
S-21 : *Yes, I know, the dot.*

Based on the interview excerpt, the subject does not properly assess the credibility of other statements by giving the right reasons (based on the results of the analysis/concept), but only based on the results of the analysis, which are not detailed, so the analysis is wrong. The results of the interviews showed that the S-21 subjects were not skilled in assessing the credibility of other statements. The subject did not count outliers, so the judgment given was incorrect.

Based on the triangulation of techniques (test results and interview results) the subject of S-21 **needs to be explored** in evaluation question no. 2c. The subject evaluates by not properly assessing the credibility of other statements by giving the right reasons (based on the results of the analysis/concept), only based on the results of the analysis, which are not detailed.

3.1.3. Description of Mathematical Critical Thinking of AR Student

In question no. 2d, subject S-30 **can** make **inferences**. This is shown by the results of the work in Figure 6 below.



It's up to them where they want to go, if you want to go to a more stable area, go to Purbalingga

Figure 6. Work Results S-30 no 2d

Based on Figure 6, the subject identifies the necessary information and draws logical and realistic conclusions. The subjects seemed skilled in identifying the necessary information and drawing logical conclusions by identifying information based on the results of the analysis of temperature variations and drawing conclusions from Sigit and Kurniawan's vacation plan, namely going to Purbalingga because the temperature was more stable and tending to be realistic saying it was up to them to go.

Based on the interview excerpts, the subject of S-30 **can** make inferences. Excerpts of the researcher's interview with subject S-30 related to inference skills in question no 2d are as follows.

P : *Based on what do you conclude Sigit and Kurniawan's vacation plans?*
S-30 : *Temperature variations*
P : *What is the conclusion?*
S-30 : *Going to Purbalingga because Purbalingga is more stable, but if you want something cool, going to Magelang is more suitable.*

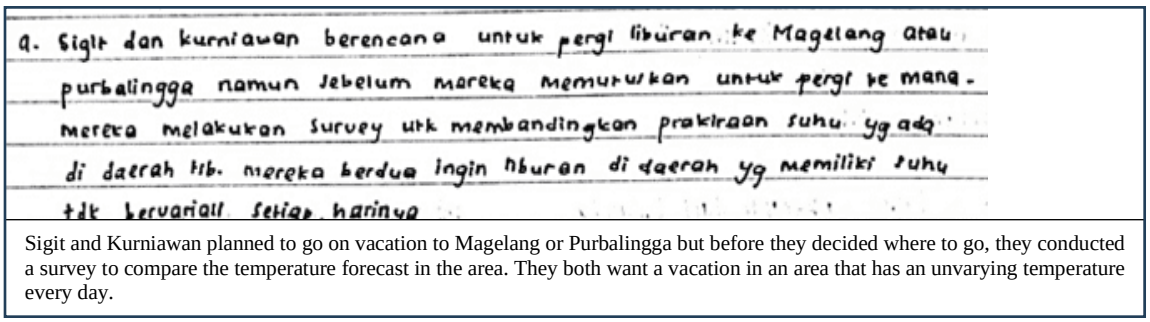
Based on the interview excerpts, the subject identifies the necessary information and draws logical and likely realistic conclusions. The results of the interviews showed that the S-30 subjects were skilled at

identifying the information necessary to draw logical conclusions. The subjects identified information based on temperature variations and drew the conclusion that they were on vacation in Purbalingga because the temperature was more stable and tended to be realistic by saying that if they wanted to go to a cool place, then Magelang was more suitable.

Based on triangulation techniques (test results and interview results) S-30 subjects **can** inferences question no 2d. Subjects make inferences by identifying the necessary information and drawing logical and realistic conclusions.

3.1.4. Description of Mathematical Critical Thinking of CR Student

In question no. 2a, subject S-30 **can interpretation**. This is shown by the results of the work in Figure 7 below.



Sigit and Kurniawan planned to go on vacation to Magelang or Purbalingga but before they decided where to go, they conducted a survey to compare the temperature forecast in the area. They both want a vacation in an area that has an unvarying temperature every day.

Figure 7. Work Results S-14 no 2a

Based on Figure 7, the subjects retell the situation of the question (Sigit and Kurniawan's plan) given using their own language. The subject appears to be skilled in understanding and explaining the meaning of the data or statement given by retelling the statement of the plan Sigit & Kurniawan gave in their own language.

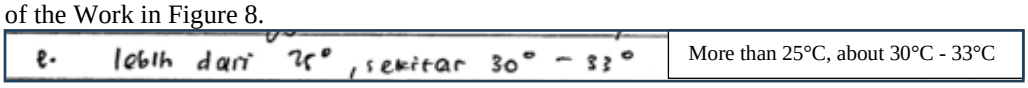
Based on the interview excerpts, the subject of S-14 **can** interpretation. Excerpts of the researcher's interview with subject S-14 related to interpretation skills in question no. 2a are as follows.

P : *Do you understand question number 2a?*
S-14 : *Understand*
P : *What is it about?*
S-14 : *Temperature forecast in Magelang and Purbalingga*

Based on the interview excerpts, the subjects recounted the data visualization (weather forecast) provided using their own language. The results of the interview showed that the subject of S-14 seemed to understand and explain the meaning of the data or statement in question no. 2a. The subject admitted that he understood and explained that the question was about temperature forecasts in Magelang and Purbalingga.

Based on triangulation techniques (test results and interview results) the subject of S-14 **can** interpret question no. 2a. The subject interprets by retelling the situation of the problem and visualizing the data provided using their own language. Subjects seem to be able to see the complete picture by retelling the situation of the problem and visualizing the data given using their own language, but tend to miss some of the moments by sometimes only telling part of it.

In question no. 2e, subject S-14 **needs to be explored** in explanations work. This is shown by the results of the Work in Figure 8.



More than 25°C, about 30°C - 33°C

Figure 8. Work Results S-14 no 2e

Based on Figure 8, the subject does not state the results and explanations based on evidentiary or conceptual considerations, but only states the results inappropriately without providing an explanation. The subject appeared to be unskilled in stating results and explanations based on evidentiary or conceptual considerations by not stating the results of 25% warmer temperature data and explanations based on analytical or conceptual evidence considerations with quartiles/box plots. The subject stated the result incorrectly without explaining.

Based on the interview excerpts, the subject of S-14 **needs to be explored** in explanation work. Excerpts of the researcher's interview with subject S-14 related to explanatory skills in question no 2e are as follows.

P : *Explain how to solve the problem?*
S-14 : *Forget that time*
P : *But did you know that the distribution of data in the box plot is Q3-max value contains 25% data, Q1-Q3 contains 50% data, and the remaining 25% data is in Q1-min value?*
S-14 : *Know because that time was explained*

Based on the interview excerpt, the subject does not state the results and explanations based on evidentiary or conceptual considerations, but only states the results inappropriately without explaining. The results of the interview showed that the subject of S-14 was not skilled in stating results and explanations based on evidentiary or conceptual considerations. The subject cannot be explained.

Based on the triangulation of techniques (test results and interview results), it can be concluded that the subject of S-14 **needs to be explored** in explanation question no. 2e. The subject explanates by not stating the results and explanations based on evidentiary or conceptual considerations, only stating the results inappropriately without explaining.

3.2. Discussion

3.2.1. Interpretation Skills reviewed from Gregorc's Thinking Style

Interpretation in mathematical critical thinking means that students are skilled in understanding and explaining the meaning of the statements or data given. By retelling data or statements using their own language, it means that students actively take in information to strengthen their understanding and be able to explain the meaning. Based on the analysis of test results and interview results, all subjects of the Gregorc thinking style type were able to retell statements (question situation) or data (data visualization) given using their own language, meaning that all types of Gregorc thinking styles and interpretation skills were categorized.

The CS subject can interpret the activities carried out to retell the visualization of the data provided using their own language and from real information. This shows that CS students absorb information that seems real. This is in accordance with Tobias (2000), who stated that the characteristic of CS thinkers is to absorb information as it is. CR subjects can interpret, with the activity carried out, is to be able to see the complete picture by retelling the situation of the problem and visualizing the data given using their own language, but they tend to miss some of the moments by sometimes only telling part. This is in accordance with Toktarova & Panturova (2015), who stated that the characteristics of the CR thinker can see the complete picture but miss some of its moment.

3.2.2. Analytical Skills reviewed from Gregorc's Thinking Style

Analyze in mathematical critical thinking is that students are skilled in identifying the relationship between problems and concepts to express information. Based on the analysis of test results and interview results of the research subjects, all types of Gregorc's thinking styles have analytical skills that are categorized as not optimal. All subjects of the Gregorian thinking style type were less skilled at identifying the relationship between problems and concepts to express information.

The CS subject has not been optimal in conducting analysis, with the activity carried out being to identify the relationship between the problem and the concept, but it tends to rely on observation and does not do detailed calculations. This shows that CS subjects reveal information from what they know through observation. This is by the CS thinking style, according to DePorter & Hernacki (2007), that reality is what they can know through the five senses. AR subjects have not been optimal in conducting analysis, with the activities carried out being to identify the relationship between problems and concepts according to the needs of the question, namely through calculations/observations, but it is not accurate due to misconceptions and a lack of thoroughness. This is in accordance with Najiyah & Mahmudah (2025) who stated that AR subjects are able to explain the concept or method used to solve the problem. In addition, according to Firdaus et al. (2019), the mistake made by students with AR thinking style is not being careful in identifying the statements in the problem.

3.2.3. Evaluation Skills reviewed from Gregorc's Thinking Style

Evaluation in mathematical critical thinking is that students are skilled in assessing the credibility of other statements. The assessment of a statement or claim will be accurate if it is based on the right concept. Based on the analysis of test results and interview results of the research subjects, CS, AS, AR, and CR students have evaluation skills in different categories. AS subjects whose evaluation skills are categorized as possible, CR subjects whose evaluation skills are categorized as needing to be explored, while CS and AR subjects whose evaluation skills are categorized as not being maximized.

The AS subject can evaluate the situation, with the activity carried out to assess the credibility of the statement by providing reasons based on the results of the analysis. This shows that AS subjects can use the results of the analysis as well-researched information to assess the credibility of other statements. This is in accordance with Tobias (2000) who stated that AS thinkers use information that has been researched appropriately and well. The subject of CR needs to be explored in conducting evaluation, as the activity carried out is not to assess the credibility of other statements correctly by giving reasons based on the results of the analysis or the right ones, but only judging based on inappropriate concepts. This is in accordance with DePorter & Hernacki (2007) who stated that CR students have a strong drive to find alternatives and do things their own way.

3.2.4. Inference Skills reviewed from Gregorc's Thinking Style

Inference in mathematical critical thinking is that students are skilled in identifying the information needed to draw logical conclusions. Based on the analysis of test results and the results of interviews with research subjects, all types of Gregorian thinking styles have inference skills that are categorized as can. All subjects of the Gregorc style of thinking type conclude according to the identification of the information they process.

AS subjects can make inferences, with activities carried out to identify the necessary information and draw logical conclusions by analyzing. This shows the AS subject analyzing information before drawing conclusions. This is in accordance with Toktarova & Panturova (2015) who stated that AS types, before making a decision, analyze the problem thoroughly using logic. AR subjects can make inferences, with activities that are carried out to identify the necessary information and draw logical and realistic conclusions. This is in accordance with Munahefi et al. (2020), who stated that the characteristics of type AR are intuitive, realistic, innovative, and follow instinct.

3.2.5. Explanation Skills reviewed from Gregorc Thinking Style

Explanation in mathematical critical thinking is that students are skilled in stating results and explanations based on evidentiary or conceptual considerations. The conceptual evidence can be obtained from the results of interpretation, analysis, evaluation, and inference that have been carried out previously. Based on the analysis of test results and interview results of the research subjects, CS, AS, AR, and CR students have explanation skills in different categories. AS subjects whose explanation skills are categorized as possible, AR subjects whose explanation skills are categorized as not optimal, while CS and CR subjects whose explanation skills are categorized as needing to be explored.

The AS subject can explain the results and provide explanations based on the consideration of analytical and conceptual evidence. This shows that the AS subject in stating the results is accompanied by evidence from the results of his analysis of the information conceptually. This is in accordance with the characteristics of the AS type of thinking style according to DePorter & Hernacki (2007), who state that the characteristics of the AS type are conceptual thinking and analyzing information. The subject of CR needs to be explored in explanation work, with the activities carried out not stating results and explanations based on evidence or conceptual considerations, only stating results inappropriately without providing conceptual explanations, and tending to use their own methods. This shows that CR subjects have difficulty explaining the results they obtained. This is in accordance with Toktarova & Panturova (2015), who stated that the CR type has difficulty in explaining the process of obtaining results.

Based on the description above, CS subjects as a whole make mistakes in critical thinking, caused by the subjects being less able to apply concepts, even though the subjects understand concepts. This can be caused by the stimulation of analysis, evaluation, and explanatory learning in the Flipped Classroom, carried out in groups. In fact, according to Toktarova & Panturova (2015), the CS type is quite difficult to work in a group and maintain dialogue. So it is necessary to carry out individual stimulation, also to

maximize the mathematical critical thinking skills of CS students. The AS subjects as a whole seem to have superior critical thinking skills to other Gregorian thinking styles, this is evidenced by the SA subjects who are able to do explanatory. This is in line with the results of research by Myers & Dyer (2006), which states that students with the AS type show significantly higher values of critical thinking skills than students with other characteristics of Gregorian thinking styles. Overall, AR subjects were able to apply the concepts they knew, only the subjects experienced a slight misconception, so the results given were less than optimal. This can be due to the fact that in Flipped Classroom learning with the help of Google Site, it appears that AR students are less likely to summarize material than students of other types and based on observations of AR students who are not focused during learning, this can cause a lack of understanding of AR subject concepts. In fact, Munahefi et al. (2020) said that the characteristics of type AR, namely an irregular way of learning, feel limited when placed in a highly structured environment. So, based on this, more direction and attention are needed for students with AR thinking styles. Overall, CR subjects in working on the questions tend to use other methods that are not in accordance with the concept of solving the problems. Based on this, CR subjects require more stimulation of mathematical critical thinking with individual problem-solving exercises. In fact, according to Toktarova & Panturova (2015) the CR type learns best in the process of problem solving and situation analysis, preferring to work under pressure in a challenging environment, but on their own.

4. Conclusion

The results of the study show that in Flipped Classroom learning with the help of Google Site, students' mathematical critical thinking varies based on Gregorc's thinking style. CS students can do interpretation and inference, but they are not optimal in analysis and evaluation, and need to be explored in explanation. AS students can interpret, evaluate, infer, and explain well, but they are not optimal in analyzing. AR students can be in interpretation and inference, but not at the maximum in analysis, evaluation, and explanation. Meanwhile, CR students can perform interpretation and inference, but they are not optimal in analysis, and need to be explored in conducting evaluation and explanation. The detailed description appears in Table 2 for each student with Gregorc's style of thinking.

One of the reasons for the lack of critical thinking skills of CS students is that they are not skilled in applying concepts when solving critical thinking problems. Teachers should give students the opportunity to solve critical thinking problems individually, not always in groups, with the guidance of teachers. One of the reasons for the lack of critical thinking skills of AS students is due to a lack of thoroughness. Teachers should remind students to reflect on the results of their work. One of the reasons for the lack of critical thinking skills of AR students is due to misconceptions. Teachers should give a variety of perspectives on the concepts learned so that students can avoid conceptual mistakes. One of the reasons for the lack of critical thinking skills of CR students is the difficulty of explaining the process of getting results. Teachers should give students more opportunities to present their work, so that students are used to conveying the thought process in a coherent and logical manner.

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