

The Flow of Analytical Thinking High Cognitive Level Students in Mathematics Problem Solving

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ARTICLE INFO

Keywords:

Analytical Thinking;
High Cognitive Level;
Mathematics Problem Solving

Article history:

Received 2022-04-21

Revised 2022-08-08

Accepted 2022-12-12

ABSTRACT

Analytical thinking ability Students in understanding and solving problems have not been specifically evaluated. Teachers still do not know how students solve problems using the thought process analytical, so it is not easy to make improvements in determining the right learning strategy for the concept. Study this uncover plot think analytical cognitive level students in non-routine mathematics problem solving based on stages Polya use approach qualitative for investigating mental level student at SMAN 1 Ngunut Tulungagung. Data analysis about Miles and Huberman includes data reduction, data presentation, and withdrawal conclusion. Research results show plot cognitive level student analytical thinking tall in complete problem through Step Polya (1) Understanding problem: differentiate; mention by verbally known and asked; write with mathematical models, and explain the relationship. (2) Planning solution: Organizing; state problem to in a mathematical model, choose draft math, choose a solution strategy from problem mathematics with write on the sheet work, explain the need state return problem to in the mathematical model, able explain the concept and able explain the chosen strategy. (3) Do plan solution: use draft selected math in complete problem mathematics, use the chosen strategy in solution, explain results solution by what was asked, and (4) Seeing return solution: prove the solution right, the exciting conclusion from results solution.

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1. PENDAHULUAN

Analytical thinking is one of the types of ability thinking needed in studying, studying, and mastering mathematical concepts and principles is constructed (Nasution dkk., 2017). (Trianto, 2016) gives a view of the goal think analytical, which could make it easy for students to believe logically

regarding the connection between concepts and situations they face. Ability thinks analysis can also be used as a foundation in realizing the achievement destination education math. Mudaly (2015) revealed that general education mathematics starts from elementary to secondary school. The aim is that participants educate have the ability, among others: (1) to understand draft math, explain linkages inter concept, and apply draft or algorithm by flexible, accurate, efficient, and precise in solving the problem, 2) to use reasoning on patterns and traits, doing manipulation mathematics in making a generalization, compiling evidence, or explain ideas and statements mathematics; (3) Solve problems that include the ability understand problems, designing mathematical models, solving models, and interpreting the solution obtained; (4) Communicating idea with symbols, tables, diagrams, or other media for clarifying state or problem; and (5) Have attitude value utility mathematics in life, namely desire to know, care, and interest in learning mathematics, as well attitude tenacious and trusting self in solving the problem.

Based on some of the opinions above, mathematics lessons function as a vehicle to train analytical thinking in instilling concepts and linking one idea to another to have the ability to solve problems and have an attitude of appreciating the usefulness of mathematics in real life.

The ability to think analytically, the soul in mathematics for some schools, is still neglected. For example, at SMA Negeri 1 Ngunut Tulungagung. Based on pre-research observations, the power of think analytical students to understand and solve problems has not been specifically evaluated. Teachers still do not know whether students solve problems using analytical thinking or not. So that teachers have difficulty making improvements in determining appropriate learning strategies for specific concepts or materials.

Remembering the importance of mathematics analytic thinking, it is necessary to train students at school to learn mathematics. In other words, if students can function level think the analysis in learning mathematics, then students are capable of understanding and solving questions with cases different from examples provided by the teacher.

Firdaus dkk. (2019) revealed analytical thinking is the students' thinking ability to describe, detail, and analyze the information used for understanding knowledge with use mind and mind logically, not at the bottom right? Feeling or guess. You, thinking analytically, require the ability to think logically in conclusion to certain situations. Logical thinking could be interpreted as the ability to think students for interesting valid findings according to rule logic and prove that conclusion is proper (reasonable) and appropriate with knowledge of previously known truth.

In solving problem math, other than noticeability, think teacher analysis is also necessary to notice the ability of cognitive students. Ability cognitive is a habit somebody in To do various tasks, in particular, collecting information, interpreting information, and how information transformation is done to other people. Therefore the difference in cognitive level mathematics allows a different understanding of mathematical concepts that cause differences in determining the problem-solving strategy. That is in line with the opinion (Simamora dkk., 2018) that the ability difference in mathematics students also affects differences in ability complete problem math.

2. METHODS

This study descriptive with a qualitative approach meant to investigate circumstances, conditions, situations, events, activities, etc., the results of which are displayed in the form of report research (Moleong, 2011:6). It was done at SMAN 1 Ngunut Tulungagung class XI MIPA-3, by assigning two subjects study with cognitive level high, namely ST1 and ST2. To collect data, interview deep and analyze tasks based on time subject to solve problem math. To obtain credible data, I continuously conducted observation with triangulation and checks. Triangulation performed with method compare result data test with result data Interview to students. Data analysis referring to the Miles and Huberman model include data reduction, data presentation, and withdrawal conclusion (Sugiyono, 2017).

3. RESULTS AND DISCUSSION

Research Results

1. Understand Problem

a) Subjects High Cognitive Level -1 (ST1)

A. Misal : batu - bata yang diproduksi = x
 biaya produksi batu - bata = y
 Jika : $x_1 = 2000$ $y_1 = 1.450.000$
 $x_2 = 5000$ $y_2 = 3.550.000$

ST1 is in the stage of understanding the problem, writing down what is known using symbols, and being able to state what is known, as the expression " If you produce 2000 bricks, the production cost is Rp. 1.450.000,- and if you produce 5000 pieces, then the cost is Rp. production is Rp.3.550.000,- ".

ST1 can state what was asked as expressed " Linear equation modeling the problem, namely if you produce bricks like this, the production costs are like this " point a, " Tell me to draw a graph " point b, " Many bricks can be made if the money available is Rp. 7,000.000,- " point c, but ST1 did not write down what was asked, " I usually don't write what is asked at my job, sir " with the excuse of " custom. " ST 1 subjects are also able to explain the relationship between what is known and what is being asked, such as the expression " To find a linear equation for the problem " point a " The graph with a linear equation needs two points, so what is known as a point "point b," From what is known in make the equation run out, substitute the production cost of 7,000,000 "point c.

a) Subjects High Cognitive Level -2 (ST2)

a. misal batu bata yang diproduksi = x
 biaya produksi batu bata = y
 Jika $x_1 = 2000$ $y_1 = 1.450.000$
 $x_2 = 5000$ $y_2 = 3.550.000$

ST2 is in the stage of understanding the problem, writing down what is known using symbols, and being able to state what is known, as the expression " If you produce 2000 bricks, the production cost is Rp. 1.450.000,- and if you produce 5000 pieces, then the cost is Rp. production is Rp.3.550.000,- ".

ST2 was able to state what was being asked as expressed " Linear equation modeling the problem of this many bricks and their production costs " point a, " Tell me to draw a graph " point b, " If the money available is Rp. 7,000,000, - how many stones bricks that can be made " point c, but ST2 does not write down what is asked, " I usually don't write what is asked in my work sir " with the reason " It takes too long and also saves processing time. " ST2 is also can explain the relationship between what is known and what is being asked, such as the expression " To find a linear equation for the problem " point a " The graph with a linear equation needs two points, so what is known as a point "point b," From what is known, an equation is made After that, the production cost substitution is 7,000,000 " point c.

b) Ability Think Analytical High Cognitive Level (HCL) Students In Stage Understand Problem

HCL students write down what they know that tend to use modeling. It means HCL students in step understand problems and carry out cognitive processes organized (*organizing*).

HCL students did not write down what was asked but could state what was asked verbally. They say "custom, and to be faster in the process," which means they *hide* the information that needs to be presented. *Hiding here is another* thinking ability. HCL students can also explain the relationship between what is known and what is asked.

HCL students in the stage of understanding the problem tend to concurrently (not in detail) and hide important information under the pretext of going faster in the work process. (Nasution, 2003: 11) says that think analytical in progress step by step and every step that assert could explain to other people. So there is an indicator think analytical that HCL students do not achieve.

1. Plan Solution

a) Subjects High Cognitive Level -1 (ST1)

A. Misal : batu - bata yang diproduksi = x
 biaya produksi batu - bata = y
 Jika : $x_1 = 2000$ $y_1 = 1.450.000$
 $x_2 = 5000$ $y_2 = 3.550.000$

ST1 in the stage of planning a solution, restating the problem in a mathematical form or model, such as the subject phrase "First, let me assume that bricks are produced with symbols x and symbolize the cost of producing bricks with symbols y . Next, I suppose $x_1 = 2000$ then $y_1 = 1.450.000$ and $x_2 = 5000$ then $y_2 = 3.550.000$ ".

$$\frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1}$$

Persamaan garis melalui titik $(2000, 1.450.000)$ dan $(5000, 3.550.000)$
 * Grafik dibalikinya

ST1 choose the concept of straight-line equations in solving problems using strategies or formulas $\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1}$. ST1 said, "The concept of straight-line equations because the questions asked in point a are linear equations and later point c also need this equation." ST1 using the formula $\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1}$ With the reason "Faster than other formulas." For point b questions, ST1 uses the two-point strategy (of the known) to draw the graph.

At the stage of planning the completion of ST1, choose mathematical concepts (straight line equations) in solving mathematical problems by looking at the modeling that has been made. Next, ST1 determines a strategy or settlement method that is easier and faster in the settlement process compared to other techniques.

b) Subjects High Cognitive Level -2 (ST2)

a. misal batu bata yang diproduksi = x
 biaya produksi batu bata = y
 Jika $x = 2000$ $y_1 = 1.450.000$
 $x_2 = 5000$ $y_2 = 3.550.000$

ST2 is in the stage of planning a solution, restating the problem in a mathematical form or model, such as the subject phrase "I suppose bricks are produced with symbols x and symbolize the cost of producing bricks with symbols y . Next, I suppose $x_1 = 2000$ then $y_1 = 1.450.000$ and $x_2 = 5000$ then $y_2 = 3.550.000$."

Handwritten work showing two points and the slope formula:

$$\begin{array}{l} \text{Jika } x_1 = 2000 \quad y_1 = 1.450.000 \\ \quad \quad \quad x_2 = 5000 \quad y_2 = 3.550.000 \\ \hline \frac{x_2 - x_1}{y_2 - y_1} = \frac{y - y_1}{x - x_1} \end{array}$$

b. persamaan garis melalui titik (2000, 1450000) dan (5000, 3550000) grafik dibaliknya

ST2 chooses the concept of straight-line equations in solving problems. ST2 says, "The idea of a straight line equation is a linear equation because what is asked in point a." ST2 didn't write down the formula but hid the procedure and immediately worked on the problem. ST2 said, "Maybe I forgot, but it's faster if I don't write it down, so thinking about the formula, I immediately substitute it." ST2 uses the formula $\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1}$. With the reason "It's easier, and I understand better." For the point b problem, ST2 uses a two-point strategy (from the known ones) to draw the graph. For point c questions, ST2 says, "From the equation obtained from point a."

When planning the completion stage of ST 2, choose a mathematical concept (straight line equation) in solving mathematical problems by looking at the modeling that has been made. Furthermore, ST 2 chooses a strategy or solution considered more straightforward and faster, but ST2 hides the selected formula, not written in its work.

c) Ability Think Analytical Inner HCL students Stage Plan Solution

HCL students state the problem into a mathematical model, duplicated by mentioning what is known. HCL students can choose mathematical concepts to solve mathematical problems. HCL students can choose a solution strategy, but each HCL student is different in planning a solution; ST1 writes the formula in his work, but ST2 does not under the pretext of thinking. HCL students can determine the best strategy (according to him) by looking at the best (faster) solution. Similar to what is expressed by Colin (Marini, 2014) that analytical thinking skills can be viewed from analytical thinking in problem-solving, namely, having many ideas, getting rid of the least efficient alternative, and determining the ideal choice (option) by looking at the best solution that meets the established criteria.

HCL students in the planning stage of completion tend to be done by imagining. HCL students choose strategies that are different from students' habits (Cognitive level students medium and low) in drawing graphs, for example, $x = 0$ and $y = 0$ on the equations of existing lines (from point a).

Handwritten work showing a line equation and its values at $x=0$ and $x=10$:

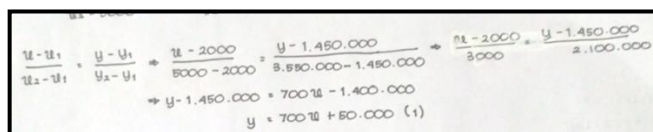
$$\begin{array}{l} \text{b) } y = 700x + 52000 \\ x = 0 \rightarrow y = 52.000 \\ x = 10 \rightarrow y = 71.000 \end{array}$$

As expressed by Tamur dkk. (2021), students with different mathematics abilities also can complete various math problems. HCL students said, "If you use it (for example, $x = 0$ and $y = 0$), it means that you count again, sir, there are easy ones. How come you are looking for difficult ones, sir. hahaha". So HCL students use their analytical thinking skills in drawing graphs.

2. Do Plan Solution

a) Subjects High Cognitive Level -1 (ST1)

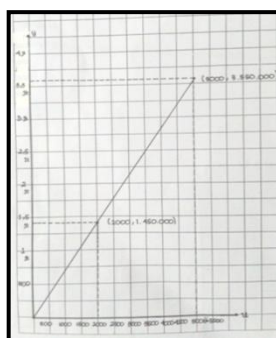
point a



$$\begin{aligned} \frac{x_2 - x_1}{y_2 - y_1} &= \frac{y - y_1}{y_2 - y_1} \Rightarrow \frac{5000 - 2000}{3.550.000 - 1.450.000} = \frac{y - 1.450.000}{2.100.000} \Rightarrow \frac{3000}{2.100.000} = \frac{y - 1.450.000}{2.100.000} \\ \Rightarrow y - 1.450.000 &= 700x - 1.400.000 \\ y &= 700x + 50.000 \quad (1) \end{aligned}$$

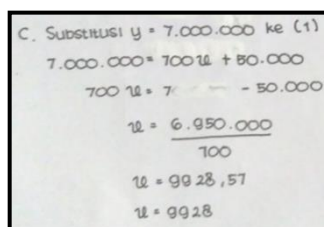
ST1 can explain the use of concepts in solving problems as the expression "Substituting what is known to the equation of a straight line if two points are known". Then ST1 uses the chosen strategy to solve the problem, "Substitute $y_1 = 1.450.000$, $y_2 = 3.550.000$, $x_1 = 2000$, $x_2 = 5000$ into the formula $\frac{y - y_1}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1}$, then simplify, cross times, and get simplified again $y = 700x + 50.000$ ".

point b



ST1 can explain the use of concepts in solving problems as the expression "The graph of a straight line can be made at least two points." Then ST1 uses the chosen strategy to solve the problem, "Making a Cartesian diagram, determining the position of the points (2000,1.450.000) and points (5000,3.550.000) then making a line".

point c



$$\begin{aligned} \text{C. Substitusi } y &= 7.000.000 \text{ ke (1)} \\ 7.000.000 &= 700x + 50.000 \\ 700x &= 7.000.000 - 50.000 \\ x &= \frac{6.950.000}{700} \\ x &= 9928,57 \\ x &= 9928 \end{aligned}$$

ST1 can explain the use of concepts in solving problems, as the expression "From the equation of the line that has been obtained from point a substituted the value of production costs Rp. 7,000,000". Then ST1 uses the chosen strategy to solve the problem, "From the equation obtained from point a where $y = 700x + 50.000$, is substituted, it $y = 7.000.000$ is obtained $x = 9.928,57$ and rounded up $x = 9.928$ ".

ST1 is in the stage of carrying out a settlement plan, able to explain the use of concepts in solving problems. ST1 can explain the concept's relevance to what is being asked, such as the expression "To find answers."

b) Subjects High Cognitive Level -2 (ST2)

point a

$$\frac{y - 2000}{5000 - 2000} = \frac{y - 1.450.000}{3550.000 - 1.450.000}$$

$$(y - 2000) 2100.000 = (y - 1.450.000) 3000$$

$$2100.000y - 4200000000 = 3000y - 4350000000$$

$$2100.000y - 3000y = -150000000$$

$$2100y - 3y = -150.000$$

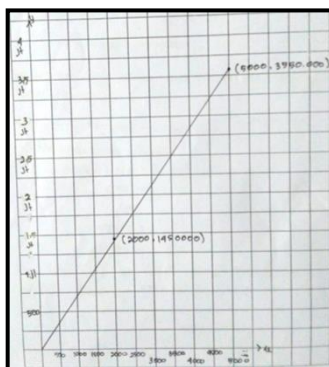
$$700y - y = -50.000$$

$$-y = -50.000 - 700y$$

$$y = 700y + 50.000 \dots (1)$$

ST2 can explain the use of concepts in solving problems, such as the expression "Substituting what is known to the formula for a straight line equation $\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1}$ ". Then ST2 uses the chosen strategy to solve the problem, "Substitution $y_1 = 1.450.000$, $y_2 = 3.550.000$, $x_1 = 2000$, $x_2 = 5000$ into the formula $\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1}$ Is obtained $y = 700x + 50.000$ ".

point b



ST2 can explain the use of concepts in solving problems as the expression "a straight line graph can be made at least two points." Then ST2 uses the strategy it chooses to solve the problem, "Make a Cartesian diagram, determine the position of points (2000,1.450.000) and points (5000,3.550.000) then draw a line".

point c

c. substitusi $y = 7000000$ ke pers. (1)

$$7.000.000 = 700x + 50.000$$

$$700x = 7.000.000 - 50.000$$

$$x = \frac{6.950.000}{700}$$

$$x = 9928,57$$

$$x = 9928$$

ST2 can explain the use of concepts in solving problems, as the expression "From the equation of the line that has been obtained from point a substituted the value of production costs Rp. 7,000,000 ". Then ST2 uses the chosen strategy to solve the problem, "From the equation $y = 7.000.000$ obtained from point a, it is substituted $x = 9.928,57$ and rounded up $x = 9.928$ ".

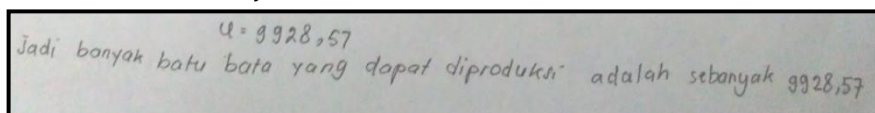
ST2 is in the stage of carrying out a settlement plan, able to explain the use of concepts in solving problems. ST2 can explain the relationship between the idea and what is being asked with the expression "To find answers."

c) Ability Think Analytical Inner HCL students To Plan Solution

HCL students use the chosen concept in solving problems by knowing the image relevant to what is being asked. Furthermore, HCL students solve issues according to the selected strategy. As expressed by (Chaowakeeratipong, 2012:18), analytical thinking is an individual ability to classify and distinguish a problem into sub-problems and determine the logical relationship of the issues.

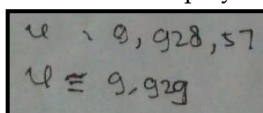
In point c questions, HCL students can specify the value of x . This thing to the opinion of Hardy (Marini, 2014) that analytical thinking is students' thinking ability to describe and detail.

If it is $y = 7.000.000$ substituted to $y = 700x + 50.000$ then it should be $x = 9.928,57$



But given that it is a lot of bricks and uses the unit of bricks in whole numbers, the HCL students round to 9.928. one of the HCL students said, "There are a lot of bricks, sir. When the bricks use a comma, the bricks are destroyed, hahaha," with a joke. HCL students answered.

So many analytical thinking skills can be revealed from point c. another process involves the analytical thinking ability, namely the rounding method. If 9.928,57 it is rounded to an integer, the result is 9.929 because the number "5" behind "8" is rounded up by one digit.



The rounding is done in this case because the available money is only Rp. 7,000,000 - if it is rounded up, the money will be more than Rp. 7,000,000,-. One of the HCL students said, "If you round up the money, who do you use, sir? Hahaha," HCL students jokingly answered. It means HCL students, in doing plan solution capable link results solution with what was asked.

3. Looking Back on the Solution

a) Cognitive Level Subject Height-1 (ST1)

$$y = 700x + 50.000 \quad (1)$$

Jadi, batu bata yang dapat dibuat jika uang tersedia Rp. 7.000.000,- adalah 9928 biji

In reviewing the completion stage, ST1 is sure of the answer by proving it, as the expression "Substitute the value $x = 2000$ to $y = 700x + 50.000$. The value $y = 1.450.000$ as well as if I substitute the value $x = 5000$ into $y = 700x + 50.000$, the value $y = 3.350.000$ " point a, "Because point b only takes what is known without calculation, so I check whether the position of each point is correct "point b, "If I substitute the value $x = 9.928$ to $y = 700x + 50.000$ then the value of $y = 6.999.600 < 7.000.000$. if I replace the value $x = 9.929$ to $y = 700x + 50.000$ then the value $y = 7.000.300 > 7.000.000$ "point c.

b) Subjects High Cognitive Level -2 (ST2)

$$y = 700x + 50.000 \quad (1)$$

Jadi batu bata yg dapat dibuat jika uang tersedia Rp. 7000000 adalah 9928 biji

In the stage of reviewing the settlement, ST 2 is sure of the answer by proving it, as the expression " Substitute the value $x = 2000$ to $y = 700x + 50.000$ then the value $y = 1.450.000$ as well as if I substitute the value $x = 5000$ to $y = 700x + 50.000$ the value $y = 3.350.000$ " point a," " Checking each point " point b, " If I substitute value $x = 9.928$ to $y = 700x + 50.000$ then value $y = 6.999.600 < 7.000.000$. if I replace the value $x = 9.929$ to $y = 700x + 50.000$ then the value $y = 7.000.300 > 7.000.000$ "point c.

c) Ability Think Analytical Inner HCL students Looking Back on the Solution

HCL students are confident in their respective answers by proving that the completion results are by what was asked.

Firdaus dkk. (2019) say, to be able to think analytically, it is necessary to have the ability to think logically in concluding a situation. Logical thinking can be interpreted as students' thinking ability to draw valid conclusions according to the rules of logic and can prove that the findings are accurate.

HCL students can conclude from the results of the completion. In completing the settlement results, students sometimes cannot finish it. If they have already gotten the settlement results, most students assume it is the final result.

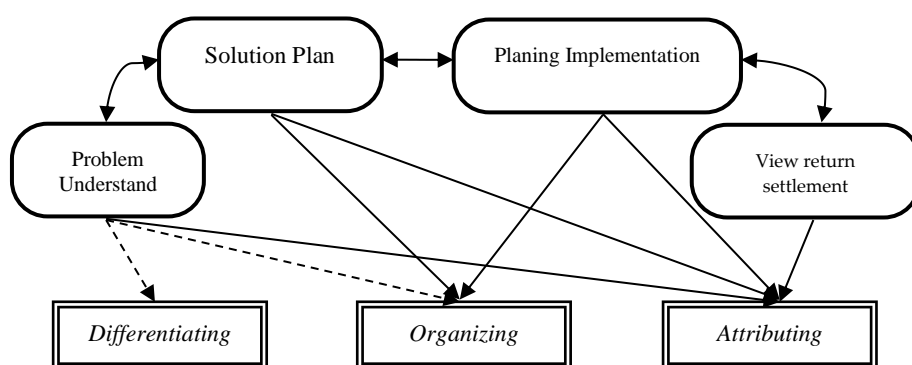


Chart 2. The flow of Thinking Analytical In Solution Trouble Mathematics Based on Stages Polya ST1 subject

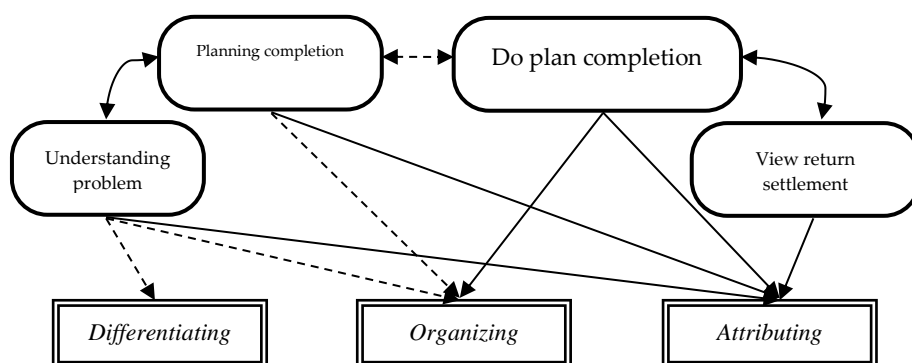


Chart 3. The flow of Thinking Analytical In Solution Trouble Mathematics Based on Stages Polya ST2 subject

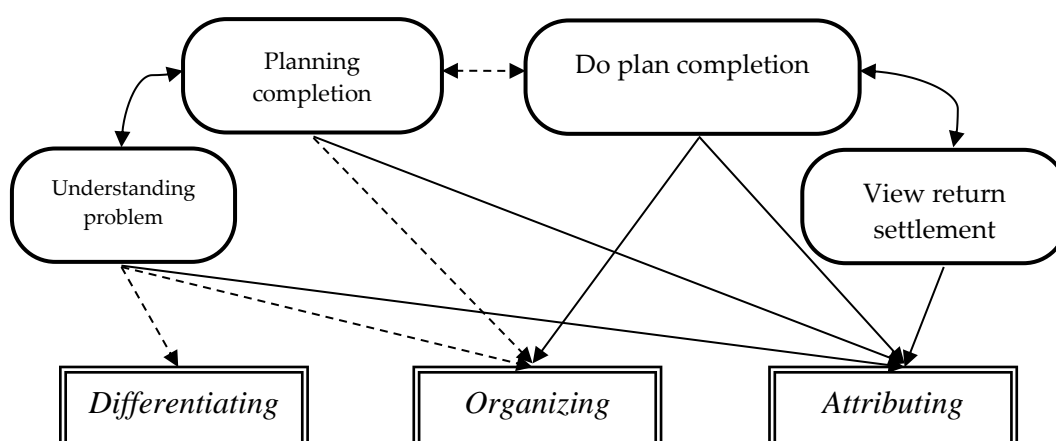


Chart 4 Flow of Thinking Analytical Inner HCL students' Solution Trouble Mathematics Based on Stages Polya

Research Results

According to (Ramadani & Supardi, 2021), analytical thinking is an ongoing thought process step by step, and every effort is stated clearly and unequivocally based on existing rules so that they are explained to others. For example, think analytical to explain the rules of cross multiplication on the fractional numbers each step based on applicable regulations. Barrett dkk. (2015) revealed that analyzing involves breaking up or sorting objects into small parts and rethinking the relationship between elements, between each component, and the overall structure. The goal of analyzing includes learning to determine which pieces of information are relevant or essential (distinguishing), determining ways to organize those pieces of information (organizing), and choosing the purpose behind the statement (assigning attributes). Thus, analyzing includes cognitive processes of distinguishing, organizing, and setting characteristics. These processes must be sequential; before students carry out the process of giving attributes, they must first determine and organize.

Mairing (2017) reveals that a problem is a situation faced by a person or group that requires a solution but does not have a direct way of determining the solution. While Simamora dkk. (2018) said: problems faced could be said problem if the problem the no can answer straight away because must select more information (data) first, and the answer obtained not category routine problems (no move/transform from form sentence typical to sentence mathematics).

Analytical thinking in solving mathematical problems includes cognitive processes such as differentiating, organizing and attributing in solving mathematical problems. The possibility of analytical thinking flow of high cognitive level students in solving mathematical problems is needed, a combination of analytical thinking indicators and indicators of the stages of solving mathematical problems using the Polya model.

4. CONCLUSION

Based on the results of research and discussion, it is concluded that the thinking ability of students at a high cognitive level (HCL) in solving non-routine math problems based on Polya stages in class XI MIPA-3 SMA Negeri 1 Ngunut Tulungagung, namely 1) Understanding problem: Differentiating; verbally mention what is known and what is being asked, Organizing; write down what you know with a mathematical model, Giving Attributes; explain the relationship between what is known and what is asked. 2) Planning completion: Organizing; stating the problem into a mathematical model,

choosing mathematical concepts in solving mathematical problems, choosing a strategy for solving mathematical problems, but there is a possibility not write it on the sheet work, Giving Attributes; explain the need to restate the problem in a mathematical form or model, be able to explain the chosen concept, be able to explain the chosen strategy. 3) Do plan completion: Organizing; using selected mathematical concepts in solving mathematical problems, using selected strategies in solving. Giving Attributes; explain that the settlement results are by what was asked. 4) View return settlement: Giving Attributes: proves that the result of the settlement is proper and concludes from the results of the solution.

Acknowledgments: Thanks to UIN Sayyid Ali Rahmatullah Tulungagung, Ma'arif NU Islamic Institute (IAIMNU) Metro Lampung, SMAN 1 Ngunut Tulungagung and all respondents who have participate in this study.

Conflicts of Interest: Writers state that in a study, there is no conflict of interest.

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