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The matthayom and senior high school student's metacognition profile on solving pisa test shape and space content based on van hiele level

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Abstract. Profile of the students' metacognition observed in this research was an activity that involved the abilities and metacognition processes of the students at each level of van Hiele thinking, including knowledge of metacognition and metacognition settings in solving geometrical problems in shape and space content. This type of research was descriptive with qualitative approach. Descriptive research was used in this research because it described or explained the variables studied, namely the level of van Hiele and Metacognition in schools in Indonesia and Thailand. The data collection methods used were van Hiele, PISA and interview tests. The results of the data analysis found that the students of visual level in Indonesia and Thailand in the planning stage were able to think about what to do, but in the monitoring stage, the students asked themselves questions about the purpose of the problems. However, in the evaluation stage they still doubt of what they decided, the students of analysis level in Indonesia and Thailand in the planning, monitoring and evaluation stages were quite sure of what they have thought.

1. Introduction

Education is very important for human life. Education has an understanding of the changing process of behaviour of a person or group of people in an effort to mature humans through teaching and training efforts, the process of expansion and how to educate. Mathematics is one of the important subjects in education. As proof, mathematics is taught at each level of education ranging from elementary school to college. Mathematics is an important element in our lives, so learning mathematics is very necessary. Geometry may become a subject that is hard to understand because it is constructed from abstract structures [1]. Communication both in oral and written languages are essential for the students to meet the new standards [2]. Meta-cognitive is important to have for every student because through meta-cognitive, the students are able to express ideas of thinking verbally and in writing contained in solving mathematical problems. Mathematics and geometry have different content, the metacognitive awareness of the students can change in these lessons [3].

Submission of opinions, conceptual understanding and selection of appropriate strategies, alternative solutions are thought ideas, all structured to solve mathematical problems. The results of PISA test and surveys in 2015 involved 540,000 students in 70 countries. From the results of the 2015 PISA test and evaluation, the performance of Indonesian students were still relatively low. Program for International Student Assessment (PISA) is held every three years at the end of the lower secondary education [4]. Consecutive mean scores of Indonesian students' achievement for science, reading and mathematics were in rank 62, 61, and 63 out of 69 countries evaluated. In learning geometry, critical thinking and

reasoning are needed, as well as logical abstraction ability. Basically, geometry material will be easily understood by the students compared to other branches of mathematics. The topic of geometry is still considered difficult by most of the students [5]. There are differences in the characteristics of the metacognition process in high, medium and low ability students in solving mathematical problems [6]. Metacognition of geometry is a person's ability to control their thought processes in observing based on the levels of geometrical thinking[7]. The students who have the ability to think about their thoughts are more effective than those who do not because metacognition is the ability to think about their thoughts that makes a person's thoughts clear [8].

The development of metacognition is not an automatic process, but is the result of a long process of development of the cognitive system [9]. Metacognition is a form of cognition [10], the second or higher level of thought processes that include active control over the process of cognition, In terms of metacognitive knowledge dimensions, Metacognitive knowledge has many similarities with knowledge cognitive, geometry is the space where children live and move [11]. Performance do not contribute to emotions apart from hopelessness [12]. In this space, children must learn to find out, explore, fight, conquer, plan and manage life (in order to live), to breathe (breathe) and to do better (move better) in it). The subjects with high intrapersonal intelligence have a positive dominant character, that are able to make appropriate planning steps and have high self-confidence so they are able to solve problems, therefore their answers are correct.

2. The Method

The type of this research was a descriptive study with qualitative approach. Descriptive research was used because this research described or explained the variables studied, namely the level of van Hiele and Metacognition. The approach used in this study was qualitative approach because the data collected were in the form of words presented in the sentences or non-numeric. The description referred in this research was the metacognition profile of matthayom and high school students in solving PISA questions in shape and space content in terms of van Hiele levels. The subjects in this research were the 4th grade students of Streesmutprakan School and the students class X of SMAN Kencong. In this research, the subjects chosen were the students of Matthayom 3 Streesmutprakan School, Thailand and High School students class X of Kencong, Jember.

The research subjects consisted of 6 students based on van Hiele test level 0, 1 and 2 only for each school. The subjects were obtained by giving van Hiele test questions which then the results were categorized based on the levels of visualization, analysis and informal deduction, for the students of deduction and rigor levels, the researcher did not find them in these two schools. The level determination used van Hiele level test problem so that it did not need to be re-validated because its validity had been proven. After categorizing the results of van Hiele test, the selection of the subjects from each category was made for one student. One subject from each category was taken by choosing one student with better English language skills, because interviews were needed when conducting the research for each level. This was done to find out whether or not there were differences in the results of written or oral tests at the interview of each level.

3. Result

The PISA test questions used in this research consisted of three items cited from the PISA questions in 2015, but it was limited to geometry questions only. The validations used for the PISA geometry test questions including the content validation, language, time allocation and instructions. Before determining the subjects of the research, it was necessary to determine the level of van Hiele students of Matthayom 4 and also high school students of class X. The determination of the level of van Hiele done by providing tests [13]. The van Hiele level determination test did not need to be validated because it was already valid. The test consisted of 25 questions in which each question reflected each stage in van Hiele level. If the students could solve 3 questions in the first 5 questions, then the student have had met the level of visualization. If the students also completed 3 questions in the second 5 questions, then the student reached the level of analysis. If the students were able to solve 3 questions in 5 third

questions, then the students reached the level of deduction, then if they were able to complete 3 questions in the 5 fourth questions, then they reached the level of informal deduction, and if the students completed 3 questions in the fifth 5 questions, then the students reached the rigor level, the student needed to meet the previous level to be able to continue to the next level.

If a student solved 3 questions in 5 third questions, but he could only solve 2 questions in the first 5 questions, then the student was categorized as a pre-visualization level, because he was not able to fulfil 3 questions in the first 5 questions. Van Hiele test was carried out by the students in 60 minutes time allocation in the Matthayom 4 classroom at the Streesmutprakan School and in the 10 Class in SMAN Kencong. The results were obtained from 132 students of Matthayom 4 at Streesmutprakan School in Thailand and the percentage of pre-visualization, visualization, analysis, and informal deduction were 28%, 44%, 23% and 5% respectively. There were no students of deduction and rigor categories found. Furthermore, the results obtained from 327 X grade students at Kencong High School of pre-visualization, visualization, analysis and informal deduction were 10%, 62%, 20% and 6% respectively. There were also no students of deduction and rigor category found in the research.
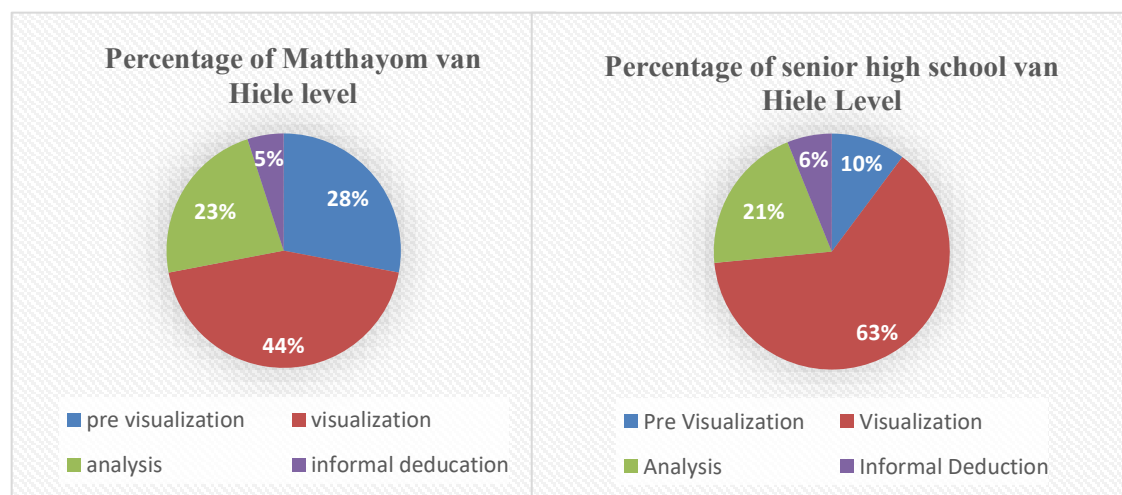

Figure 1. Percentage of Matthayom and senior high school van Hiele Level.

After obtaining the data of students' level based on van Hiele's level, then the students were grouped in several levels and three students from each school were selected as research subjects which represented each level. The level taken in the study was informal visualization, analysis and deduction. It was in line with the consideration that the six subjects chosen were based on van Hiele level and their ability to speak and understand English. As a result, there were six students chosen.

Table 1 Research Subject.

No.	Student's Code	Category
1.	SS1	Level 0 (visualization) SMA
2.	SS2	Level 1 (analysis) SMA
3.	SS3	Level 2 (informal deduction) SMA
4.	SM1	Level 0 (visualization) Matthayom
5.	SM2	Level 1 (analysis) Matthayom
6.	SM3	Level 2 (informal deduction) Matthayom

After getting the research subject, the next stage was conducting an interview. The six students were interviewed alternately and analyzed how their thinking processes were in resolving a standard PISA question on geometry of shape and space content material.

4. Discussion

The analysis of students' meta-cognition profiles was based on the students achievement of each indicator based on the test results and interviews that strengthen the overall results of the students' meta-cognition profiles analysis. The following were the results of the analysis of students' meta-cognition profiles:

4.1. Analysis of Visual Level Meta-cognition

The profile of SS1 who was the representative of level 0 group namely visualization in high school and SM1 who was the representative of the level 0 group namely visualization in Matthayom. The following were the results of the SS1 and SM1's tests and interviews along with the analysis.

4.1.1 SS1 Test and Interview Results

From SS1's answers, it seemed that he lack of understanding related to the function of the graph and was not quite able to understand the questions in number 1. SS1 answered incorrectly by answering A, but during the interview SS1 explained confidently and still chose A as the answers after being given explanation by the researcher. It can be seen from the question number 1 that the answer should be D, SS1 still believed the answer was A by giving an explanation. Then, in the question number 2, SS1 answered correctly and in accordance with the indicator that the students was able to compare and sort the shapes based on their overall appearance through comparing congruent AQP triangles with RQP triangles and the explanation was that both triangles had the same sides and could form parallelogram lines. SS1 was able to mention several reasons to identify the parts of the structure, but he did not analyse the structure based on the properties of the components. He saw in their entirety in which this can be seen in the SS1 interview excerpt that fulfilled only several meta-cognition indicators at the level of visualization in interview excerpt below.

> SS1 01.08   : In my opinion A
> P 01.09   : why the A?
> SS1 01.11   : Because it matches the speed
> P 01.13   : Right?
> SS1 01.14   : Yes, you can go up and down
> P 01.16   : yes, for example? can be explained maybe for a while I look for
> the   questions themselves, well this is the number 1 problem
> yes can be   explained earlier
> SS1 01.28   : Yes, starting from here, I equate it here
> Q 01.37   : Yes, that means that what is appropriate is A?
> SS1 01.39   : A

The indicator achieved by SS1 was the student was able to think and knew what was known. This was conveyed when SS1 was asked a question by the researcher to get clarify the answers given during the written test. It can be seen in the interview excerpt, SS1 explained again what had been written on the test, SS1 explained "In my opinion A, because according to the speed, yes it can go up and down " which meant that the graph in the question number 1 fluctuated according to the figure.

The first indicator that became a reference to see SS1 meta-cognition profile for level 0 had not been achieved because the student was not able to identify things about shapes through its overall appearance, the students had not been able to construct, draw or copy a shape and the student had not been able to name or give other label and configuration using standard and / or non-standard names that are suitable as well. Therefore, the student did not fulfil the indicator of van Hiele level. It was reviewed through meta-cognition indicators in planning the student's thinking to be able to know what was known and what was asked. In monitoring, the student asked questions to himself about what was known in the problem and in the evaluation the student decided whether the information obtained about what was already known was correct, although the answer from SS1 was wrong.

4.1.2   SM1 Test and Interview Results

The first indicator that was used as a reference to see SM1's meta-cognition profile for level 0 had been achieved because the student was able to identify things about shapes through its overall appearance,

the student was able to construct, draw or copy a shape and the student was able to name or label the building and the other configuration using appropriate standard and or non-standard names. Therefore, the student fulfilled the indicator of van Hiele level. It was reviewed through indicators of meta-cognition in planning student's thinking to be able to know what was known and state the problem by using his own sentences or other forms. In monitoring, the student was able to monitor the sentences used in restating the problem which did not come out of the original purpose of the problem and in the evaluation the student decided that the sentence statement made was in accordance to the original purpose of the problem. It was proven by the correct answers of the student, even though student's writing was not clear, the answer used his own sentences or in other forms. This is in accordance that a student at this level only accepts the picture given [1]
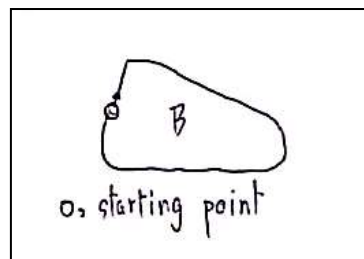

Figure 2. SM1 answers in identifying shapes based on what shape he saw entirely.

SM1 used written language accompanied by an explanation of the figure, yet he did not explain that the figure had met the speed and adjusted for the estimated image. At the time of writing, the answer SM1 was lack in describing answer B. Even though the answer of SM1 was correct, in the interview SM1 could not explain about the questions given by the researcher. The student at the visualization level could meet several indicators existed in van Hiele level [14].

4.2   Analysis of analysis level metacognition

Analysis of SS2 who was the representative of level 1 of high school students obtained from the van Hiele test. SM2 was the representative of level 1 of Matthayom students. The following were the results of the SS2 and SM2 tests and interviews along with analysis.

4.2.1   SS2 Test and Interview Results

In the second problem, SS2 wrote that congruent triangles were congruent PQR triangles with CRQ triangles because if the two triangles were seen in the figure if the diagonals were drawn then it made the triangles congruent. Then the triangle was congruent because the facing angle was equal i.e. the QRP angle was equal to the CRQ angle. In addition, the opposite angles were the same magnitude, including the PQR angle was the same as the CRQ angle and the CQR angle was the same as the PRQ angle.

> P 08.27   : *looking for congruent structures which are congruent from*
> *questions what is number 2? wake up which one?*
> S 08.33   : *PQR, PQR is congruent with CQR*
> P 08.39   : *then?*
> S 08.40   : *APQ is congruent with PQR*
> P 08.45   : *heem then?*
> S 08.46   : *PBR is congruent to PQR*
> P 08.51   : *why is it called congruent? you mentioned earlier. Why ? how come*
> *it's called congruent*
> S 09.00   : *the sides are the same, the sides are the same length, the angles are*
> *corresponds equally*

In the interview excerpt, it can be seen that SS2 fulfilled several indicators including remembering and using the term correctly for components and the relationship between the components. SS2 compared two forms based on the relationship between its components and SS2 also found specific properties significantly and generalize the properties. It can be seen from the SS2's interview excerpt which explaining how the triangle was said to be congruent accompanied by the reasons. In the meta-

cognition profile of SS2 in the planning stage, SS2 thought that he would look for any relationship between the data and what was asked, SS2 also thought that he would look for how to solve similar problems and see the solution as a comparison. At the monitoring stage, SS2 asked what initial knowledge needed to be used. Moreover, at the evaluating stage, SS2 decided the initial knowledge to solve the problem.

4.2.2   Test and Interview Results of SM2

The first indicator that is a reference in seeing the meta-cognition profile for level 1 for SM2 had been achieved because the student was able to compare two forms based on the relationship between its components. He was able to sort forms in various ways based on certain traits, including sorting examples and not examples in a class, as well as he was able to discover the properties of the unusual artificial class and solve geometrical problems by using known awareness or through deep insight. So the student matched the van Hiele level indicator. If students are not in a particular level of Van Hiele model they might not be able to perceive what the teacher sees in a geometric situation so higher levels of understanding is required [15].

If reviewed through meta-cognition indicators, in the planning stage, students were able to think that they would find any relationship between the data and what was asked and students were able to think they would look for solutions to similar problems and saw their solutions as a comparison. In monitoring, the students chose a formula that might be used to match the data obtained and observe similar problem solving steps. Whereas in the evaluation, students decided that the relationship between the data and what was asked was correct and decided on a suitable formula to use. It was proven by the students' correct answers.

On figure 4.4 it can be seen that the SM2 used a comparison of each build accompanied by an explanation of the figure, only it did not explain that the figure had met the speed and adjusted to the estimated image. When writing the answers, SM2 was lacking in writing information even though the answer was correct. At the time of the interview, SM2 was able to explain the answers of questions given by the author.
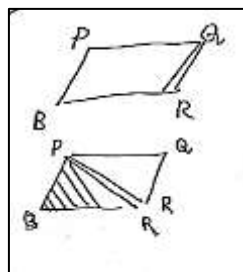

Figure 3. The form of the SM2 subject's answers based on the form they see entirety

4.3 Metacognition Analysis of Informal Deduction level

SS3 research subjects were group representatives with the level 2 category of informal deduction and SM3 research subjects were group representatives with the level 2 category of informal deduction at Matthayom high school. Following are the results of the SS3 and SM3 tests and interviews with their analysis.

4.3.1   SS3's Test and Interview Results

SS3 subjects in solving problem number 3 were able to meet or reach 2 van Hiele level indicators. This was due to SS3 being able to identify different sets of traits that characterized a class of shapes and checked that that was enough. SS3 also explained in the interview excerpt about the relationship of squares and triangles that formed a prism and there were other relationships in the cube in the prism that was described as a related cube. Based on the results of completion and interviews SS3 found the properties of the building by identifying the components observed in the form of lines/sides, angles and other attributes that accompanied the building. Students more easily understand the nature of building through realistic models and forms in their entirety. Also determined the relationships between components so that naming could be found in accordance with the characteristics of the shape. SS3

explained that the squares and triangles in the figure formed a prism. So that SS3 was able to identify the different sets of traits that characterized a class from building and checked that it was sufficient. SS3 in its metacology showed the relationship between what was known and what was being asked and determined the strategy or method to be used in solving the given problem. It can be seen in the following interview excerpt.

> *P 14.31 : right.. okay.. okay.. question number 3, the last question*
>
> *S 14.35 : Okay,if the measurement of the base of the pyramid in the model did not change, but the edges AT, BT, CT and DT were all 15m and E, F, G, and H remained as midpoints, would the length of EF change? Justify your answer.*
>
> *P 15.03: What is the answer?*
>
> *S 15.05 : Hmmm they tell me about this length change into 15 meters and G E F and H is the midpoint of 15 meter and then he ask me about*
>
> *P 15.26 : The length of EF*
>
> *S 15.29 : The length of EF, it is in my opinion, it's in 15, if it is 15 meters it will be 7.5 and then it would be 7.5 too*

SS3 met several indicators in metacognition which was SS3 thought that he would take steps to resolve steadily and thought that he would make improvements if he found an error. SS3 in the monitoring phase was able to carry out and monitor corrective measures if it encountered an error. And in the evaluating stage SS3 was able to decide that the examination results were correct and SS3 decided that the results obtained were in accordance with what was asked. In metacognition, the main interest is the notion of judgment accuracy which is a measure of a person's awareness of their cognitive abilities [15]

4.3.2 SM3's Test and Interview Results

The first indicator that was used as a reference in seeing the metacognition profile for level 2 for SM3 has been achieved because students were able to identify differences in the set of characteristics that characterized a class from building and checked that it was sufficient, students were able to provide informal reasons (using diagrams, pieces of building that can be folded or other material). So students matched the van Hiele level indicator. On Figure 4, it can be seen that SM3 tried to work with various perspectives and formulas that might be able to obtain the right and correct results. SM3 also tried to make the results obtained in accordance with what was asked. However, at the time of the interview, SM3 was unable to explain the reason of his answer.
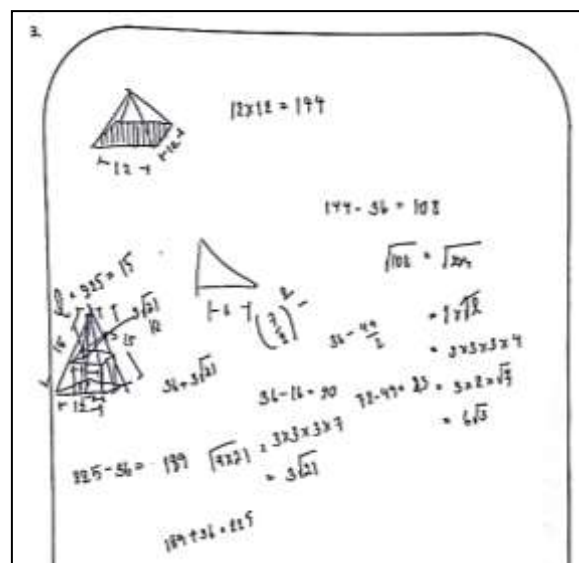

Figure 4. SS3 subjects' answers in identifying a set of different properties that characterize the class of a structure.

If it is reviewed through metacognition indicators, in planning stage, students were able to think they would make completion steps steadily and students were able to think they would make improvements if they found mistakes. In monitoring, students carried out and monitored corrective steps if they found an error. While in the evaluation stage, students decided the results obtained were in accordance with what was asked and students decided the improvements made were able to correct errors that arose. The indicators achieved by the subject are as follows which are presented on the following table 2.

Table 2. Percentage of Student Achievements on van Hiele Indicators.

No	Students	Indicator Achieved			
		Visualization (%)	Analysis (%)	Informal Deduction (%)	Metacognition (%)
1.	SS1	50			66,67
2.	SM1	50			66,67
3.	SS2		66,67		66,67
4.	SM2		66,67		83
5.	SS3			50	66,67
6.	SM3			50	66,67

Based on the result of the study, students' metacognition profile which was examined through van Hiele level and metacognition stages still on the average category. Students' should get used to do the PISA test shape and space content based on OECD [16]. Students should get used to surpass metacognition stages through van hiele geometry test [17].

5. Conclusions

Based on the result and discussion, there was a development of students' characteristics based on the criteria of van Hiele's geometry thinking stage on the aspect of metacognition in the process of planning, monitoring and evaluating. It was obtained that SS1 and SM1 subjects reached 50% indicators at the visualization stage and 66.67% at metacognition indicators. SS2 and SM2 reached 66.67% of the indicators at the analysis stage and the SS2 at the metacognition indicators that were 66.67% and for SM2 were 83%. SS3 and SM3 reached 50% of informal deduction indicators and 66.67% of metacognition indicators. Characteristics of students' metacognition processes with the stage of thinking visualization started from identifying geometric shapes, manipulating whole shapes, defining conjectures through the attributes used, and naming geometric shapes. Students also did the monitoring which was done in the previous stage. The monitoring carried out was focused on the problem observation activities. Students at the stage of analytical thinking had the characteristics of a complete metacognition process, students have appeared to show visuospatial abilities through analytical activities, synthesis by identifying visually and spatially constructed.

Acknowledgments

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