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# Exploring the elementary school's teacher's perception of students 'mathematical thinking in mathematics teaching

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**Abstract.** Mathematical thinking serves as a core of mathematics instruction in schools. These research goals were identified 1) The elementary school's teacher's perception about thinking based on Bloom's Taxonomy in mathematics instruction, and 2) The elementary school's teacher's perception of scientific approach in mathematics learning. This research was descriptive-qualitative. Data were obtained by using open-ended questionnaire methods for nine fifth-grade elementary teachers and passive participation observation toward two fifth-grade elementary school teachers in Semarang. The result 1) the elementary school's teacher's perceptions about the students' thinking is that in theory and practice, the teacher has sufficient knowledge and facilitates the students' thinking of remembering aspect and applying optimally to the students, and 2) Elementary school teachers' perception about the scientific approach is in theory and practice the teacher understands and applies the observing, questioning, associating/ processing information/ reasoning, and communicating facilitations, but practically of collecting information, teacher's facilitation is still less varied. The professional teachers noticing students' mathematical thinking must be studied and developed in mathematics teaching.

## 1. Introduction

Bloom's Taxonomy is one of the most famous taxonomies in the educational system. Bloom's taxonomy is a classification of educational objectives and originally intended to facilitate communication among examiners, as well as others involved in educational research and curriculum development [1]. Bloom's Taxonomy as a framework uses a multi-tiered scale to organize the levels of expertise required to achieve measurable student outcomes. Bloom's original taxonomy consisted of six classification levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. This taxonomy was revised by Anderson & Krathwohl and called The Revised Bloom's taxonomy (RBT) consist of Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating [2]. This taxonomy has been developed to teach teachers how to classify a given learning assignment and how to define and grade learning objectives [3]. This taxonomy helps teachers in planning educational goals and learning experiences. It means that this taxonomy can be used for identifying learning outcomes, teaching and learning process (for example [4], and assessment of teaching (for example [5]) The real contribution of Bloom's Taxonomy in the specification of the educational objectives is carried out by teachers concerning the levels of the thought process from simple tasks to complex tasks [6].

Based on [7] research, many primary teachers and their institution are confused about the content and implementation of the 2013 Curriculum related to four dimensions of knowledge in Bloom's Taxonomy (i.e. factual, conceptual, procedural, and metacognitive knowledge). Most test items designed



by teachers only cover factual and conceptual knowledge and rarely include procedural and metacognitive knowledge in their assessments. Based on [8] research, the objectives in the information technologies and software curriculum are mostly under the understanding in the cognitive process dimension and they are mostly under the procedural knowledge dimension. Table 1 below describes 19 cognitive processes in six categories of cognitive processes in Bloom's Taxonomy.

**Table 1.** The Cognitive Processes based on Bloom's Taxonomy [9]

Category of Cognitive Processes	Cognitive Processes
A. Remember	1. Recognizing (locating knowledge in long-term memory that is consistent with presented material)
B. Understand	2. Recalling (retrieving relevant knowledge from long-term memory)
	3. Interpreting (changing from one form of representation to another)
	4. Exemplifying (finding a specific example or illustration of a concept or principle)
	5. Classifying (determining that something belongs to a category)
	6. Summarizing (abstracting a general theme or major points)
	7. Inferring (drawing a logical conclusion from presented information)
	8. Comparing (detecting correspondences between two ideas, object, and the like)
C. Apply	9. Explaining (constructing a cause-and-effect model of a system)
	10. Executing (applying a procedure to a familiar task)
D. Analyze	11. Implementing (applying a procedure to an unfamiliar task)
	12. Differentiating (distinguishing relevant from irrelevant part or important from unimportant part of presented material)
	13. Organizing (determining how elements fit or function within a structure)
E. Evaluate	14. Attributing (determining a point of view, bias, values, or intent underlying presented material)
	15. Checking (detecting inconsistencies of fallacies within a process or product; determining whether a process or product has internal consistency; detecting the effectiveness of a procedure as it is being implemented)
	16. Critiquing (detecting inconsistencies between a product and external criteria, determining whether a product has external consistency; detecting appropriateness of a procedure for a given problem)
	17. Generating (coming up with alternative hypotheses based on criteria)
F. Create	18. Planning (devising a procedure for accomplishing some task)
	19. Producing (inventing a product)

In Indonesia, the country has followed 2013 curriculum since the academic year 2013/2014. This curriculum is based on Regulation of Ministry of Education and Culture Republic of Indonesia No. 21 of 2016 [10], which concerns the content standards of elementary and secondary education, and identifies three graduate competencies: attitude, knowledge, and skill. These three competencies are further broken down into four dimensions, or core competencies: spiritual, social, knowledge, and skill. Then, the basic competencies of knowledge and skill core competencies break down in Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 37 of 2018 [11]. The elementary teachers in elementary school describe the basic competencies of this knowledge and skills into indicators of competency achievement. The description is adjusted for the six cognitive categories of Bloom's Taxonomy.

Primary school teachers' perceptions of Bloom's Taxonomy in the implementation of mathematics learning need to be explored, developed, and studied in depth. So that the teacher is right in providing mathematical activities to students so that they develop mathematical thinking.

Based on the regulation of the minister of education and culture Number 22 of 2016 [12] concerning the standard of the primary and secondary education process, the learning process is held interactively, challenges, motivates students to participate actively, is strengthened by an integrated thematic scientific approach (thematic between subjects), and thematic (in a subject) and is directed at developing the three graduate competencies as a whole/holistically. The student-centered learning process through a

scientific approach includes activities to observe, ask questions, dig information, process information, and communicate those that touch the realms of attitudes, knowledge, and skills. This means that elementary school teachers provide activity facilitation so that students can observe, ask questions, gather information, process information, and communicate.

The 2013 Curriculum socialization activities including the socialization of the scientific approach and Bloom's Taxonomy in learning have been implemented by the government. The development of learning tools that implement a scientific approach has also been written by many teachers and is part of educational research. The application of Bloom's Taxonomy in the evaluation of learning has also been socialized and described in the formulation of competency achievement indicators. The formulation of the research problems are 1) how is the elementary school's teacher's perception about thinking based on Bloom's Taxonomy in mathematics instruction, and 2) how is the elementary school's teacher's perception of the scientific approach in mathematics learning.

The activities carried out by the teacher in this study were developed based on Table 1. The following Table 2 describes teacher activities as the implementation of the six categories in Bloom's Taxonomy.

**Table 2.** Teachers Activity as the implementation of six categories in Bloom's Taxonomy

No.	Category of Cognitive Processes	Cognitive Processes	Teachers Ask Students to:
1	Remembering	Recognizing	mention examples and not examples of the concept that have been or are being studied or the understanding of the concept that has been studied draw according to the concept that has been studied identify the characteristics of the mathematical concept do listing show examples and not examples of the concept give the name of the plane figure and solid figure mark the characteristics of the concept read the history of the mathematical concept/literature about mathematicians
		Recalling	memorize mathematical formula/the understanding of certain mathematical concept/characteristics of a certain mathematical concept note the material that is being studied/questions and answers of the material that are being studied repeat the steps to solve the mathematical problem as the teacher did
2	Understanding	Explaining	explain the relationship between concepts in mathematics detail the characteristics of the definition/concept in detail explain the concept discuss to find the concept
		Classifying	categorize something like the example or not example in mathematical concept give the example of the application of the concept differentiate one concept from the others which are interrelated restate the relationship between concepts
		Comparing	compare the characteristics of some related mathematical concept calculate in solving the problem
		Interpreting	change the story problem into mathematical form and vice versa expand the question of the problem make a mathematical pattern based on the contextual problem
3	Applying	Executing	apply the concept in solving a routine problem determine the solution to the problem assign the students to apply the concept in solving the task calculate in solving the problem of concept application

No.	Category of Cognitive Processes	Cognitive Processes	Teachers Ask Students to:
4	Analyzing	Implementing Organizing	demonstrate something to find the concept derive formula based on the existing formula modify the problem and solve it analyze the task to find the concept/analyzing the relationship between mathematical concepts in nonroutine problem solving correlate one concept with another concept make diagram of the relationship of one mathematical concept with another mathematical concept detail the steps of problem-solving in sections
		Attributing	test the existing formula or theorem or problem-solving solve nonroutine problem
5	Evaluating	Checking	consider something in solving the problem to make a decision assess the logic of the work done by herself/himself or friends compare to get the conclusion conclude based on the calculation in solving a contextual problem predict based on the existing pattern Interpret mathematical symptoms, mathematical model into a daily situation consider making a decision justify the finding obtained
6	Creating	Generating	abstract contextual problem into a mathematical problem combine one mathematical concept with another mathematical concept in solving a nonroutine problem
		Producing	make the animation on a certain material  develop the task instructed by the teacher create a certain product that applying the mathematical concept create the steps to solve the problem in an unusual way/solution of an unusual problem

The activities of the scientific approach in this research are described in Table 3.

**Table 3.** Learning activities for the implementation of a scientific approach

No	Scientific Approach	Students activity
1	Observing	observing natural phenomena, objects, etc. as an introduction to the explanation of a concept reading books related to mathematicians reading the history of a mathematical concept watching videos/shows related to the concepts being learned
2	Asking question	asking questions to the teacher to re-explain the material discussed asking the teacher about things that they do not understand about the material being studied asking the application of a mathematical concept in everyday life asking the process of working on a math problem asking based on keywords created by the teacher submitting math problems according to the concepts being studied
3	Gathering information/experiment	collecting information employing experimentation to answer questions gathering information by reading other learning resources to answer questions reading other sources observing objects to answer questions discussing to answer questions
4	Processing information/ associating / reasoning	using the data obtained to answer questions thought of answering the question
5	Communicating	conveying answers to questions (conclusions) orally submitting answers to questions (conclusions) in writing

## 2. Methods

This study used a descriptive qualitative method. The study was conducted in the academic year 2018/2019. The first agenda was a Focus Group Discussion with fifth-grade elementary school teachers to obtain descriptive data of teachers' perception of scientific approach and thinking concept for mathematics learning. The teachers filled out an open-ended questionnaire. This activity was attended by 9 fifth grade teachers from 9 elementary schools in Gunungpati Semarang. The second agenda involved the research conducted at two elementary schools. This phase described the reality of the fifth-grade elementary school teacher acts as the implementation of six categories in Bloom's Taxonomy and scientific approach that occurred in the field. The elementary schools involved were Plalangan 01 public elementary school and Pakintelan 01 public elementary school in Gunungpati Semarang. Observation of the implementation of mathematics learning in each of the schools was carried out four times during face-to-face learning in August – September 2018 with the materials being taught were "distance, time, speed", and "fraction". The result of the second phase is a technical triangulation of the result of the first agenda.

## 3. Results and Discussion

### 3.1. Result

3.1.1. *The elementary school's teachers' perceptions about students mathematical thinking based on Bloom's Taxonomy in mathematics instruction.* Based on technical triangulation from open-ended questionnaires and observation mathematics teaching in two schools, we got the teachers' activity as the implementation of Bloom's Taxonomy done by teachers as Table 4 below for facilitating students thinking.

**Table 4.** Teachers' activity based on Technical triangulation

No.	Category of Cognitive Processes	Teachers Ask Students to:
1	Remembering	mention examples and not examples of the concept that have been or are being studied or the understanding of the concept that has been studied draw according to the concept that has been studied identify the characteristics of the mathematical concept memorize mathematical formula/the understanding of certain mathematical concept/characteristics of a certain mathematical concept note the material that is being studied/questions and answers of the material that are being studied repeat the steps to solve the mathematical problem as the teacher did
2	Understanding	calculate in solving the problem change the story problem into mathematical form and vice versa
3	Applying	apply the concept in solving a routine problem determine the solution to the problem assign the students to apply the concept in solving the task calculate in solving the problem of concept application
4	Analyzing	analyze the task to find the concept/analyzing the relationship between mathematical concepts in nonroutine problem solving
5	Evaluating	consider something in solving the problem to make a decision
6	Creating	abstract contextual problem into a mathematical problem

In the lowest Category of Cognitive Processes, remembering, 11 teachers acted for facilitating students' remembering. Based on the results of the questionnaire and field research, only 6 acts were done by the teacher. The first act was the teacher's activity asking the students to mention the examples and not examples of the concepts that had been/were being studied and mentioning the understanding of the concepts that have been studied. For example, the students gave examples of even and odd numbers; triangle images; objects that were plane figures and not plane figures; an example of a multiplication operation is the repeated addition of a number ( $3 \times 4 = 12$  and  $4 + 4 + 4 = 12$ ). The

example of a teacher's activity asking the students to mention the understanding of the concepts that had been studied was the teacher giving the question "What are odd numbers and even numbers?"; the students were asked to explain the figure of right angle; the students were asked to mention the plane figure. When the teachers in one school taught the distance, time, and speed materials: the teacher asked the students to give the example of the use of distance units (the students answer that distance unit was used to measure the length of the highway and used the unit of km; the distance of house A to the school was close while the distance house B to the school was far. Does A or B go to the school first?); the teacher asked the students to copy the change of time unit other than 1 hour = 60 minutes, and the students answered that  $\frac{1}{4}$  hours = 15 minutes; some students were asked to mention travel time from home to the school. Another teacher asked the students to mention the formula of speed; mentioned the sequence of the distance from km to mm.

Another teacher's acts for facilitating students to remember were; 1) ask the students to memorize the mathematical formula, 2) memorize the understanding of the certain mathematical concept, and 3) memorize the characteristics of the certain mathematical concept. For example, students were asked to memorize the area and perimeter formulas of the square; after the area formula of the triangle was found then the students were asked to memorize the area formula of the triangle. After the students were asked to note the concept of the formula found, they were asked to memorize (the formula of the surface area and volume of the cylinder/solid figure, the formulas of the plane figure and solid figure, formula of the area of the square, and the formula of the perimeter of the rectangle. The teachers in SDN Pakintelan 1 asked students to memorize the sequence of the distance units, the students memorized the distance units using a song. The teachers in SDN Plalangan 1 also asked the students to memorize the speed formula, which was distance divided by time, sing a song.

Based on questionnaires and observations of classroom learning, the two teachers always facilitated students to think in the cognitive understanding process. However, of the 13 activities designed, only 2 were always carried out by the teacher. Furthermore, 4 out of 7 activities were carried out by the teacher to facilitate the cognitive process applying.

In the cognitive process analysis, there were 6 activities designed. But, there was only an activity conducted by the teacher in the learning, that was the teacher's activity asking the students to analyze the task to find the concept. It meant that the teacher rarely gives the activity that requires the students to think of analyzing aspects. Result occurred likewise in evaluating and creating. Based on the results of the questionnaire and field research on the evaluating process, there was only one of 8 activity conducted by the teacher in the learning, that was the teacher's activity asking the students to consider something in solving the problem to make the decision. Likewise in the cognitive process of creating, only 1 out of 6 activities were performed by the teacher. Namely abstracting the contextual learning in the mathematical form.

### *3.1.2. The elementary school's teacher's perception of the scientific approach in mathematics teaching.*

Based on the questionnaire, the teachers were able to identify students' activities for observing as listed in Table 3. It showed that the teacher understood the facilitation form of the students' observing activity. The activity of reading the book related to the mathematician conducted by reading or find out how to get the formula, reading the book about the mathematician. The activity of reading the history of the concept as a form of observing activity was conducted by finding out the biographer of the mathematicians and reading the history of mathematical concept finding. Students were watching the learning video about the mountain and connecting it with a solid figure such as a cone, watching a learning video about arithmetic so that the students learned to count faster, and watched the video on how to make compost. Field research of the fifth-grades class of Plalangan 01 public elementary school and Pakintelan 01 public elementary school Semarang showed that the teacher's facilitation in scientific approach was varied. For the observing activity, the teacher not only asked the students to observe the information presented in the students' books but also asked the students to observe the picture made by the teacher (distance unit stairs). The teacher used the learning video to explain fractions, distances, speeds, and times.

The teachers knew that the questioning activity included asking the questions to the teacher to re-explain the material discussed, asking the teacher about the material studied that were not yet understood, asking about the application of the mathematical concept in daily life, asking the working process of the mathematical concept, asking based on the keywords made by the teacher, and asking the mathematical problem according to the concept studied.

The teacher found out that the collecting information/experimenting activity could be done by experimenting to answer the question; answering the other learning resource to answer the question; reading the other learning resource to observe the object to answer the question and discussing. But, in field research, the students only used the information that had been stated in the problem and did the discussion. They were not accustomed to collect the information/try from the other learning resource or experimenting. Also, the teacher found out that the associating/processing information/reasoning was conducted by using data obtained to answer the question and think to answer the question, but most of the teachers had not been able to give the example in the mathematical learning. Based on the field research, the students' associating/processing information/reasoning activity was facilitated by the teacher by giving the guided question stimulus. The students could answer the question given well. The teacher knew that the communicating activity included conveying the answer to the question (conclusion) verbally and in writing. For example, the students presented their work result and answered the teacher's question directly and wrote the answer on the worksheet, and wrote the conclusion of the discussion result. Based on the field research, it was known that the students could communicate their answers verbally and in writing.

### 3.2. Discussion

*3.2.1. Discussion of the elementary school's teachers' perceptions about students mathematical thinking based on Bloom's Taxonomy in mathematics instruction.* Class teacher activities were conducted in facilitating students to remember various types. The highest percentages of cognitive processes in two coursebooks (English for Students of Science and English for the Students of Engineering) was remembering process and the lower-level processes of the cognitive domain in Bloom's Taxonomy were dominant presenting than the other ones [13]. At the remembering process, the mathematics teachers focused on memorizing the abilities of the learner. Learning in basic education emphasized knowledge and remembering. According to [14], knowledge is the basis of other educational goals and higher process cognitive domains based on the initial knowledge they have and remember. Remembering, understanding, and applying mathematics knowledge give a positive effect on the students' mathematics achievements [15]. Other researchers stated that students' ability to think in the memory process was better than the other five cognitive processes in each dimension of knowledge [16].

In Bloom's Taxonomy, the lower cognitive processes were controlled by students, so higher cognitive processes could be achieved [17]. But in fact, the ability of students to apply cognitive processes did not have to be preceded by the ability to understand. The ability of students to apply mathematical concepts in solving mathematical problems was not always preceded by an understanding of mathematical concepts because students only use the correct algorithms for the math problems they were working on [18]. Based on this, the teacher did not focus on varying the activities so that students understand the concept (4 cognitive processes consisting of 13 teacher activities). The teacher only focused on 2 cognitive processes, namely comparing and interpreting, and only one teacher activity on each cognitive process. Both teacher activities were carried out with frequent frequency in teaching mathematics in class.

The teacher's act for facilitating student's analysis, evaluating, and creating were very rarely. This was because teachers rarely gave HOTS questions in learning. Associated with Bloom's Taxonomy, HOTS was a problem measure ability the analyze, evaluate, and create [19]. The teacher rarely gave the activity that required the students to think of creating an aspect. This was because the teacher focused on the understanding ability of the concept. Therefore, the teacher had to maximize the giving activity



that requires the students to think of creating aspects. The other activity form had never raised in mathematical learning in the class. Class teachers in primary schools must have had in-depth knowledge and understanding of mathematical, pedagogical, and psychological competencies because they were the first to help students develop understanding, skills, and attitudes towards mathematics. Teacher competence, work methods, and attitudes affected student achievement at the basic education level [20].

*3.2.2. Discussion of the elementary school's teacher's perception of the scientific approach in mathematics teaching.* Instructional videos in mathematics learning emphasized cognitive aspects, increased student interest, and motivation to learn [21]. Students needed to be accustomed to learning through observation. Students in grades 3 to 5 of United States primary schools learn by observing and learning through observation was useful when they progress to secondary school and higher education [22]. This was because studying in secondary schools and higher education provided many learning opportunities for students through observation. Learning by observation was the main method of acquiring skills. Based on the results of the questionnaire, the teacher classified reading activities as observing activities. However, in observing classroom learning practices, both teachers did not ask students to read books. Teachers needed to familiarize students with reading books, especially books related to mathematics. Textbooks were an important learning resource in learning mathematics in elementary schools and mathematics textbooks contribute to student achievement [23]. There were five styles of reading mathematics textbooks, namely —close reading with strong connections, close reading with some connections, scanning, skimming, and avoiding [24]. For further research, teachers needed to identify the types of reading mathematics textbooks of their students and got used to reading according to the types.

But in the observation of mathematics learning in class, students rarely took the initiative themselves to ask questions. The teachers gave opportunity students especially quiet students to ask their questions in private, one on-one setting, in person, and through e-mail [25]. The teacher must have identified the type of student, namely vocal, responsive, bilateral, and silent to further provide different stimuli according to that type so that students wanted to ask questions [26]. Teachers familiarized elementary school children ask more informative questions [27].

Based on the field research, the teacher did not only ask "Is there any question?", but also trained the students to ask the question by problem-posing activity. Students in groups (4 people) made the contextual mathematical problem of the distances, speeds, and times materials. Each group was enthusiastic in carrying out the task and the mathematical problems made by them were very good although the problems made did not measure high-level thinking. It only measured their understanding of the concepts of distance and time. The teacher gave several integers, fractions, percent, and decimal, then the students were asked to ask the question based on the numbers. The stimulus given by the teacher was problem posing. The teacher also trained the students to ask by giving the homework. Students were asked to ask their parents about the distance between home and school and also the traveling time.

#### 4. Conclusion

Based on this research, the following conclusions were obtained. First, the elementary school's teacher's perceptions about the students' mathematical thinking was that in theory and practice, the teacher had sufficient knowledge and facilitated the students' thinking of remembering aspects and applying maximally to the students. The teacher's knowledge about the thinking of the aspects of understanding, analyzing, evaluating, and creating still must be developed and in the practice in the class still must be developed. Second, the elementary school's teacher's perception about the scientific approach was in theory and practice the teacher understood and applied the observing, questioning, associating/processing information/reasoning, and communicating facilitations, but in the practice of collecting information, teacher's facilitation was still less varied.

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