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Bloom's Taxonomy Analyze Category: The Analysis of Students' Analytical Skills Based on Gender

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Abstract

This study aims to describe students' analytical skills based upon gender differences. Bloom's Taxonomy analyze category is the basis for determining the level of analytical skills. According to Bloom's Taxonomy, analytical skills consist of three cognitive processes: differentiating, organizing, and attributing. This type of research was qualitative, with the research subject as many as six students on the number material. This research was conducted on seventh-grade students at one of the junior high schools (SMP) in South Sumatra. Research subjects were determined reached from the results of initial mathematical abilities consisting of two students with high initial abilities, two medium early abilities, and one low initial ability. The study's results revealed that students' analytical skills of girls were better than boys. Girls fulfill all cognitive processes of analytical skills. In contrast, in solving number problems, boys only achieve some of the cognitive analytical skills process.

1. Introduction

Mathematics equips students with essential critical thinking that enables them to conceptualize, analyze, and solve more complex problems. This ability is obtained when students can solve a problem from the questions they get. Mathematics is given to all students to equip them with critical, logical, analytical, systematic, creative thinking, communication, and collaboration skills (Pratama & Retnawati, 2018). These abilities in learning mathematics are Higher Order Thinking Skills (HOTS) (Suparman et al., 2020; Widana et al., 2018).

Higher Order Thinking Skills (HOTS) is a level of questions requiring high-level thinking in learning mathematics, not only remember but also finding new ideas in a problem (Zain et al., 2022). Developing students' high-level learning is essential to education (Agarwal, 2019; Malik, 2018). Through Higher Order Thinking Skills (HOTS) questions, students will be capable to distinguish ideas, understand complex things more clearly, solve problems and formulate hypotheses, construct explanations and communicate well (Arnellis et al., 2020).

Previous research has shown that students are highly dependent on using mathematical formulas to solve mathematical problems (Edo, 2016; Gunawan & Fitra, 2021; Septian & Komala, 2019). When given a math problem, students will directly refer to which formula to use (Amina et al., 2020). This results in a lack of creativity in finding other possible solutions to solving a given problem. This is supported by the results of the Programme for International Student Assessment (PISA), which evaluates the education systems of 72 countries around the world, showing that the achievement of students' ability in mathematics competence has increased from 375 points in 2012 to 386 points in 2015 (OECD, 2019a). Indonesia only ranks 64 out of 65 countries with an average score of 375, while the average international score is 500 (OECD, 2019b). This shows that students' problem-solving skill requiring critical thinking, analyzing, reasoning, and creativity is very lacking.

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HOTS measurement aims to identify the students' highest level based off of Bloom's Taxonomy in the analysis category. This study only focuses on the analysis category because there are still many students who still have difficulty solving the problems contained in the questions (Dwidarti et al., 2019; Hebebci et al., 2020; Utari et al., 2019) and there are still students who have not met several indicators in the aspect of analyzing (C4) (Nurapipah & Zulkarnaen, 2020; Putri et al., 2020; Uchia & Yunianta, 2021). Analytical skills are essential for junior high school students (Setiawaty et al., 2019; Somatanaya & Nugraha, 2018). An analysis is an act of thinking in describing a component into a simple whole (Krathwohl, 2002). According to Krathwohl (2002), the analysis category consists of differentiating, organizing, and attributing cognitive stages.

This research is based upon gender because it refers to the different roles between men and women in society. There are differences in research results when reviewing the gender perspective on mathematical activities. Girls and boys have their respective advantages and disadvantages in doing math problems. Some studies have revealed that girls are better at mathematics (Ahmad & Sehabuddin, 2017; Babys, 2020; Davita & Pujiastuti, 2020; Nugraha & Pujiastuti, 2019; Sari & Nurfauziah, 2019). Another study also reveals that boys are better at learning mathematics (Fisher et al., 2020; Steegh et al., 2019; Uchia & Yunianta, 2021). On the other hand, some studies reveal that gender is not significantly different in mathematical activity (Kadarisma et al., 2019; Rusdi et al., 2020; Sabat & Pramudya, 2021). Even research conducted by (Kersey et al., 2018) shows that in the age range of 6 months to 8 years, there is no difference in mathematical ability when viewed from gender differences.

Many factors influence students' mathematical ability concerning gender. These factors can be either intrinsic factors or extrinsic factors. According to (Maccoby & Jacklin, 1978), the influencing factors are cognitive abilities: visuospatial, verbal, and quantitative abilities. (Zhu, 2007) explained that the factors that influence biological correlation (gender differences in lateral brain function, gender differences in brain structure, influence of sex hormones, gender differences in brain activity during information processing); psychological contributions (learning styles, attitude studies, stereotypes threat in mathematics tests); and environmental/experience influences (socioeconomic variables, sociability, differences in mathematics teaching). (Kersey et al., 2018) explains that socio-cultural influences at an early age are one of the causes of differences in mathematical abilities.

Previous research has not focused on Bloom's Taxonomy category. This study investigates the analyze category (Bloom's Taxonomy Category) mathematics HOTS problems in junior high school based upon gender. This study aims to describe students' analytical skills based upon gender differences. This study was in a position to reveal whether there are differences in analytical skills. The analysis in this study can be an adequate basis for the continuous development of new and improved studies of gender differences in mathematics.

2. Methods

This study was qualitative research. According to (Sugiyono, 2015) qualitative research methods are used to reveal the condition of objects. This study will reveal how students analyze HOTS problem that are reviewed from gender. The research subjects were seventh grade students in one of the junior high schools (SMP) in South Sumatra which were selected by purposive sampling. Subjects consisted of 5 students who had been divided reached from students' initial mathematical abilities (IMA), which included two high abilities (girl and boy), two moderate abilities (girl and boy), and two low abilities (girl). The reason for choosing class VII as the research subject was reached from the results of classroom learning observations, including teacher and student activities.

Data collection used document of subjective tests (essay tests) and interviews. The test method determines higher-order thinking skills (analyze category) by analyzing each student. The purpose of data collection was to measure students' analyzing skill HOTS problems in class VII are based upon gender.

Table 1. The Cognitive Process Dimension

Categories & Cognitive Processes	Alternative Names	Definitions and Examples
1. **Remember**: Retrieve relevant knowledge from long-term memories		
1.1 Recognize	Identifying	Looking for knowledge in long-term memory that is relevant to the given material
1.2 Recalling	Retrieving	Capture relevant knowledge from long-term memory
2. **Understand**: Construct meaning from instructional message (oral, written, diagram, and infographics)		
2.1 Interpreting	Clarifying, translating paraphrasing, representing,	Changing the form of representation (for example from pictures/diagrams to verbal)
2.2 Exemplifying	illustrating, instantiating	Find specific illustrations or examples centred on the concepts/principles already have
2.3 Classifying	Categorizing, subsuming	Determine the part/member of a category
2.4 Summarizing	Abstracting, generalizing	Abstracting a significant point(s) or general theme
2.5 Inferring	Concluding, extrapolating, interpolating, predicting	Making logical conclusions from the information provided
2.6 Comparing	Contrasting, mapping, matching	Determining the relationship between two corresponding ideas
2.7 Explaining	Constructing models	Constructing cause-effect relationships/model of a system
3. **Apply**: Carry out use a procedure in a given situation		
3.1 Executing	Carrying out	Applying a procedure to a familiar task
3.2 Implementing	Using	Applying a procedure to an unfamiliar task
4. **Analyze**: Break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose		
4.1 Differentiating	Discriminating, distinguishing, focusing, selecting	Distinguishing relevant from irrelevant parts or important from unimportant parts of presented material
4.2 Organizing	Finding coherence, integrating, outlining, parsing, structuring	Determining how elements fit or function within a structure
4.3 Attributing	Deconstructing	Determine a point of view, bias, values, or intent underlying presented material
5. **Evaluate**: Make judgments bottomed on criteria and standards		
5.1 Checking	Coordinating, detecting, monitoring, testing	Detecting the effectiveness of a procedure as it is implemented; Detecting errors in a process;
5.2 Critiquing	Judging	Detecting conformance of procedures to a given problem; Detecting inconsistencies between products and external criteria
6. **Create**: Put elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure		
6.1 Generating	Hypothesizing	Coming up with alternative hypotheses bottomed on criteria
6.2 Planning	Designing	Devising a procedure for accomplishing some task
6.3 Producing	Constructing	Inventing a product

2.1 Theoretical Framework: Blooms' Taxonomy and Revised Bloom's Taxonomy

In 1949 Benjamin S. Bloom proposed the idea of a cognitive taxonomy to create a shared learning goal (Krathwohl, 2002). Bloom's Taxonomy offers various levels of study objectives, classified according to complexity. Once students have mastered the objective level of learning through formative assessment, correctional activities and other enrichment exercises, they can then proceed to the next level (Guskey, 2010). Bloom and his team published a taxonomy in 1956. In 2001, Krathwohl, a member of Bloom's team, proposed a revised Bloom's taxonomy (Anderson & Krathwohl, 2001). Changes in Bloom's Taxonomy and Revised Bloom's Taxonomy are illustrated in Figure 1.

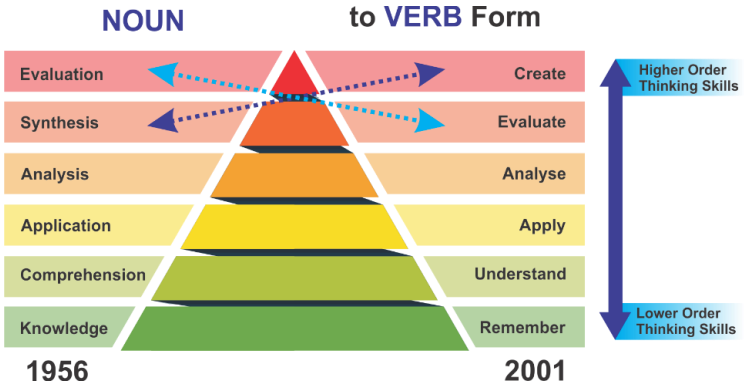


Figure 1. Blooms' Taxonomy and Revised Bloom's Taxonomy

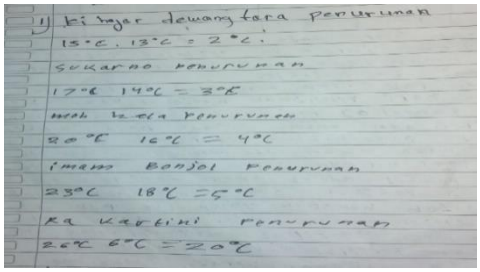
Revised Bloom's Taxonomy reflects the active learning model, uses verbs to describe the active learning process, and omits nouns used in the original version (Callister, 2010). The framework developed by Bloom and his collaborators consists of six main categories: remember, understand, apply, analyze, evaluate, and create. The detailed explanation is able to be seen in Table 1.

3. Results & Discussions

Revised Bloom's Taxonomy strengthens teachers' understanding that learning is an active process. The learning process is also vital to include measurable work patterns in each learning goal. A clear taxonomic structure emphasizes the importance of clear and concise, unambiguous, and abstract learning objectives (Shabatura, 2018). When implementing education, Bloom's Taxonomy helps teachers understand the learning process and provides more concrete guidance for creating effective learning outcomes.

This study focuses on analytical skills established on the six categories in Revised Bloom's Taxonomy. Therefore, students' analytical skills are divided into two: boys' analytical skills, girls' analytical skills, and the difference between the two. The subjects selected were students with high, low, and low IMA.

3.1. Boys' Analytical Skills



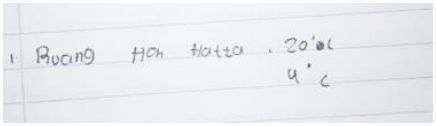
- Room Ki Hajar Dewantara, temperature drop
  15°C – 13°C = 2°C
- Room Soekarno, temperature drop
  17°C – 14°C = 3°C
- Room Moh Hatta, temperature drop
  20°C – 16°C = 4°C
- Room Imam Bonjol, temperature drop
  23°C – 18°C = 5°C
- Room RA Kartini, temperature drop
  26°C – 6°C = 20°C

Figure 2. Students M_1 answer (high IMA)

The first exposure is subject to high IMA. Acquired from the answers of M_1 in Figure 1, the students have achieved the indicators of analytical skills. In differentiating cognitive processes, M_1 can organize relevant and essential known information by noting in the given problems. However, in Figure 2, M_1 is still unsuitable for drawing that conclusion. Furthermore, in organizational cognitive processes, M_1 can manage by identifying problems and linking them to theories that have been studied previously.

In the attributing cognitive process, M_1 can contribute to describing the problems given. Figure 1 shows that M_1 already knows that to find the largest difference in room temperature, namely using the initial temperature in the Ki Hajar Dewantara room being reduced by decreasing the temperature and multiplying by the difference in temperature, namely 15 – (2 x 4) = 15 – 8 = 7°C and so on. But M_1 did not give a conclusion for the largest temperature difference in the room. The answer is correct but does not get the

maximum score because M_1 can't analyze properly. As for the work of other students, M_2 is a student who has a medium IMA. The results of the work of M_2 can be noticed in Figure 3.



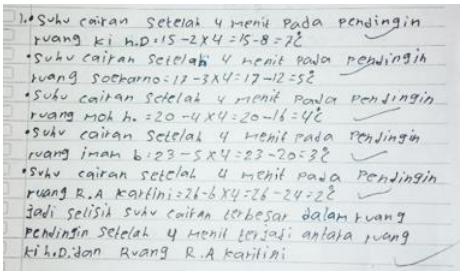
1. Moh Hatta Room 20°C
   4°C

Figure 3. Students M_2 answer (medium IMA)

Acquired from the M_2 answer, M_2 have not been able to achieve the indicators of ability in analyzing. In the differentiating cognitive process, M_2 subjects have not been able to sort out relevant and essential information. This is shown in Figure 3 that the M_2 has not written down what is known and what was asked. Furthermore, in the cognitive process of organizing, M_2 is still lacking in organizing, indicated by the lack of accuracy in identifying problems and connecting to the theory being studied. M_2 only answered Moh Hatta Room 20°C.

As for the cognitive process of organizing, M_2 is less able to attribute because it does not solve the questions asked. In the content of the answers, M_2 does not use steps in solving questions but immediately concludes the answers obtained. M_2 can still analyze the low category assumed from these three cognitive processes.

3.2. Girls' Analytical Skills

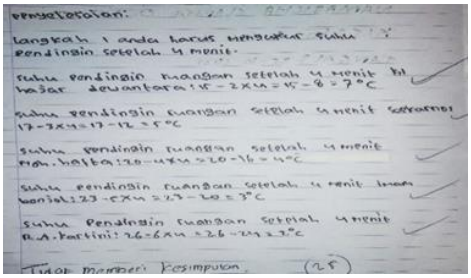


- Temperature of the liquid after 4 minutes in the room Ki H.D = 15 − 2 × 4 = 15 − 8 = 7°C
- Temperature of the liquid after 4 minutes in room Soekarno = 17 − 3 × 4 = 17 − 12 = 5°C
- Temperature of the liquid after 4 minutes in room Moh. Hatta= 20 − 4 × 4 = 23 − 16 = 4°C
- Temperature of the liquid after 4 minutes in the room Imam Bonjol = 23 − 5 × 4 = 23 − 20 = 3°C
- Temperature of the liquid after 4 minutes in room R.A Kartini = 26 − 6 × 4 = 26 − 24 = 2°C
- So, the biggest difference in the temperature of the liquid in the room after 4 minutes occurs between the room KHD and the room R.A Kartini

Figure 4. Students F_1 answer (high IMA)

F_1 is a subject with high IMA. F_1 has reached the indicator of the ability to analyze. Acquired from Figure 4, in the differentiating cognitive process, F_1 can sort out relevant and essential given information by noting the question. Furthermore, in the cognitive organizing process, F_1 can organize by identifying problems by connecting to the theory that has been studied.

In the Attributing cognitive process, F_1 can attribute to describe the given problem. It can be seen in Figure 4, F_1 already knows that to find the largest difference in room temperature, the initial temperature in the Ki Hajar Dewantara room is reduced by a decrease in temperature and multiplied by the difference in temperature, namely 15 – 2 x 4 = 15 – 8 = 7 °C and so on until the largest difference in room temperature is obtained.



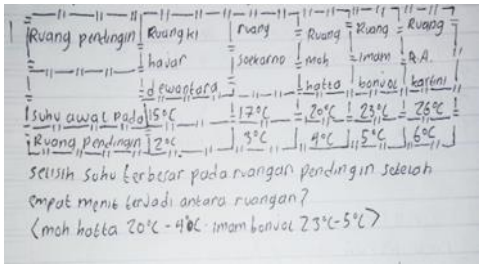
Solution
- Step 1, you should measure the temperature after 4 minutes.
- The temperature of the air conditioner Ki Hajar Dewantara after 4 minutes 15 − 2 × 4 = 15 − 8 = 7°C
- The temperature of the air conditioner Soekarno after 4 minutes 17 − 3 × 4 = 17 − 12 = 5°C
- The temperature of the air conditioner Moh. Hatta after 4 minutes 20 − 4 × 4 = 20 − 16 = 4°C
- The temperature of the air conditioner Imam Bonjol after 4 minutes 23 − 5 × 4 = 23 − 20 = 3°C
- The temperature of the air conditioner R.A. Kartini after 4 minutes 26 − 6 × 4 = 26 − 24 = 2°C

Figure 5. Students F_2 answer (medium IMA)

F_2 is a subject with medium IMA. Acquired from F_2's answer in Figure 5, F2 has also reached the indicator of ability to analyze. In the differentiating cognitive process, F_2 be able to organize relevant and

important information by noting what is known in Figure 5. However, F_2 is less precise in writing down what is being asked of the question.

Acquired from Figure 5, it can also be seen that in the organizing cognitive process, F_2 can organize by identifying problems and connecting to the theory that has been studied. Furthermore, F_2 can attribute by describing the given problem in the cognitive process of attributing. Acquired from Figure 5, F_2 already knows that to find the largest difference in room temperature, the initial temperature in the Ki Hajar Dewantara room is reduced by a decrease in temperature and multiplied by the difference in temperature, namely 15 – 2 x 4 = 15 – 8 = 7°C and so on until the largest difference in room temperature is obtained. The F_3's answer with low IMA is presented in Figure 6.



Air Conditioner	Room Ki Hajar Dewantara	Room Soekarno	Room Moh Hatta	Room Imam Bonjol	Room RA Kartini
Initial temperature	15°C	17°C	20°C	23°C	26°C
temperature drop	2°C	3°C	4°C	5°C	6°C

The biggest difference in air conditioning temperature after four minutes occurs between the rooms?
(Moh Hatta 20°C – 4°C Imam Bonjol 23°C – 5°C)

Figure 6. Students F_3 answer (low IMA)

Elicited from the results of F_3's work in Figure 6, it is known that F_3 has not yet reached the indicator of ability to analyze. In the differentiating cognitive process, F_3 has not been able to sort out relevant and essential information. In addition, F_3 did not record what was known and asked in the question. In the organizing cognitive process, F_3 is less able to organize by less precisely identifying problems and connecting to the theory being studied. F_3 only answered that the difference in room temperature was the largest after four minutes between rooms (Moh Hatta 20°C and Imam Bonjol 23°C).

Furthermore, in the cognitive process of attributing, F_3 could not attribute because it did not complete what was asked. Elicited from Figure 5, it is also known that F_3 did not use the steps in completing but immediately concluded the answers obtained. So, it can be supposed that F_3 has analytical skills in the low category because F_3 has not met the three indicators.

3.3. Differences in Analytical Skills Based on Gender

A recapitulation of the discussion of achievements in each cognitive analysis process elicited from differences in IMA in terms of gender is apparent in Table 2.

Table 2. Differences in Analytical Skills in male and female students

Cognitive Processes	Gender	
	Boys	**Girls**
Differentiating	Less able to distinguish relevant and irrelevant information in the problem (initial temperature, temperature drop, and temperature difference)	Able distinguish between relevant and irrelevant information on a problem (initial temperature, temperature drop and temperature difference)
Organizing	Able to recognize elements or information simultaneously into interrelated parts but unable to relate to integer material.	Able to recognize elements together into interrelated parts and relate to integer material.
Attributing	Able to provide a point of view, assess, and explain the purpose of a proposed problem but still unable to solve the problem	Able to provide a point of view, assess, and explain the purpose of a proposed problem

Formulated on the answer sheets and interview results, it is known that the results of boys' analytical skills are different from the girls' analytical skills. This supports research (Mohamed & Lebar, 2017) which states that higher-order thinking for an individual depends on the individual's ability to apply, develop and improve knowledge in the context of thinking. Students' analytical skills is needed to respond and find concepts to solve problems (Anggoro et al., 2021) not only at school but also to support their thinking in dealing with the real world (Anggraini & Pratiwi, 2019).

The results showed that girls were better able to meet the indicators of analytical skills than boys. This is consistent with (Stoet & Geary, 2018) that girls can be said to be better at analyzing. Both boys and girls, can solve problems well. However, boys have not been able to illustrate the steps of the problem in detail, while girls have met three indicators in analysis category.

In the cognitive differentiating process, girls are more detailed in describing the problem by writing down what is known about the problem, and this shows that girls are better able to distinguish relevant information in problems such as initial temperature, temperature drop, and temperature difference. In contrast, boys tend to be less capable in this cognitive process. This is indicated by the results of the work of subjects M_1 and M_2, who have not been able to define the known information (initial temperature, temperature drop, and temperature difference). Lack of ability in differentiating cognitive processes can affect subsequent cognitive processes in analytical skills. This supports the study of (Uchia & Yunianta, 2021) which states that girls have better analytical skills in differentiating cognitive processes. This finding is also consistent with (Anggraeni & Herdiman, 2018; Anggreini & Asmarani, 2022; Nafi'an, 2021) that girls are better at precision and accuracy and more fluent in expressing their written answers (Rusdi et al., 2020).

In the cognitive organizing process, boys and girls can recognize elements simultaneously into one interrelated part. However, in contrast to girls, boys still have difficulty connecting interrelated elements in integer material. This is consistent with the results of the study (Aminah & Kurniawati, 2018), which states that the most difficulty experienced by boys is in expressing and relating information that is known and asked. The results also show that boys have difficulty using technical, operational, formal language, and mathematical tools in the organizing cognitive process. Boys not only have difficulty communicating the problem's purpose but also face difficulties in devising the right strategy to solve the problem.

In the cognitive process of attributing, girls can provide a point of view, assess, and explain the purpose of a proposed problem. This impacts how girls choose the right way to solve problems. Besides that, boys have little difficulty in solving the problem. This could be since boys have difficulty imagining the solution method asked to solve the problem. (Rodriguez et al., 2019) stated that the ability to attribute can help students in solving problems. According to the data and interview results, girls are better in attributing to solving problems than boys. Girls are not only able to attribute to solving problems but are also able to attribute and determining the calculation operations to be used and can share conclusions.

4. Conclusion

Formulated on the results of the research and discussion on the category of analyzing in Bloom's Taxonomy for grade VII students on HOTS problems based upon gender, it was concluded that the analytical ability of girls on integer was better than boys. Differences in analytical skills were revealed in the cognitive processes of differentiating, organizing, and attributing girls are more capable than boys. In the cognitive differentiating process, girls were more detailed in distinguishing relevant and essential information on the integer problems. In the cognitive organizing process, girls could better determine how elements fit or function in a structure so that it is easier to solve problems. Unlike girls, boys still have difficulty connecting related elements in integers. In the cognitive process of attribution, girls are also more proficient than boys, who can provide perspectives, assess, and explain the purpose of a problem related to integers.

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