The Logical Thinking Ability: Mathematical Disposition and Self-Regulated Learning

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Abstract The purpose of this study was to analyze the direct effect of factors from the logical thinking ability in junior high school students in Bandar Lampung City. The research uses survey methods with path analysis techniques. Intelligence quotient (X₁), mathematical disposition (X₂), and self-regulated learning (X₃) as exogenous variables. Logical thinking ability (Y) as an endogenous variable. The results showed that 1) there is a positive direct effect of intelligence quotient towards the logical thinking ability; 2) there is a positive direct effect of mathematical disposition towards the logical thinking ability, 3) there is a positive direct effect of self-regulated learning towards the logical thinking ability.

1. Introduction
Logical thinking ability is very important because it is very useful in problem-solving and making decisions. In learning mathematics, students often face a problem or tasks that need to be solved. To solve the problem, the ability to think and the reason is needed. By thinking of using mathematical concepts, principles, and operations that have been studied, students learn to find and solve the problems. In learning mathematics, children are used to doing problem-solving using their thinking skills. Conversely, by learning to solve problems that are done step by step will improve the logical thinking ability of students. Mathematics is the knowledge of basic objects that are abstract through the consistency of truth, which is arranged regularly in accordance with the rules of reasoning or logical thinking as a result of human thought. Logical thinking ability is often referred to as reasoning is strongly related to ability in problem-solving as a result of learning. Logical thinking ability is a very important cognitive ability that affects student learning outcomes. Logical thinking in learning mathematics is helping students to develop students’ understanding abilities that are not only given facts, rules, and procedures. [1-3].

Thinking is an act of reason to "cultivate" knowledge or information that has been obtained through the five senses, aiming to achieve a truth. In addition, thinking is an activity of talking to yourself. Thinking is an activity of the soul to gain knowledge or information. In these activities the term thinking is used and the activity of obtaining information that is not yet known to use something or information that is already known. Something that has been known is information called data or understanding of thought, while something that is not yet known is called a conclusion that will be obtained from the results of thought. Through thinking activities, students can analyze symptoms, objects, and events to draw the conclusions in the form of knowledge. Based on human
knowledge obtain the truth, thinking the activity is an activity to get the truth from the right knowledge or knowledge. After that, thinking activities can be interpreted as the activity of the human mind in finding or acquiring the right knowledge. Thinking ability can produce truth that is not the same. Thinking activities with certain characteristics in getting the truth are called reasoning. It can be said that reasoning as a thinking activity to draw conclusions is called knowledge. Without logical thinking ability that is done rationally and systematically, it will not get the truth that can be accounted for [4-5]

Logical thinking is often called logic. Etymologically, logic can be seen as reasoning or the science of thought. Logic is often referred to as the science of thinking that uses laws or rules of thought. Logic is a mental activity. It is done in phases and a regular activity. The stages of the logic process begin with the formation of understanding, opinion formation, and conclusion drawing. Logical thinking activities in the scientific field are called reasoning activities or processes. Logical thinking as reasoning activities carried out according to certain logic or based on certain patterns and sequences. Logic is broadly defined as thinking activities in the assessment process that is carried out legally. Scientific activities as a whole are carried out in a system that is logical because science or science cannot be released from the interests of logic. Logic directs people to be able to think right, efficiently, straightly, and regularly to avoid being in the right to get the truth. Based on this idea, it is reflected that people use the principle of logic. They can think correctly regardless of emotions, prejudices, and beliefs when using logic. The use of logic can guide students to be objective, assertive, and courageous. Logical thinking is done in stages as a process to get conclusions using causal reasoning and is done consistently using logical inference or logic principles according to a certain pattern to draw conclusions. [6-8].

Logical thinking ability as a competency is achieved in mathematics. Logical thinking abilities can be developed through mathematical learning activities, it can be seen as learning outcomes to be achieved. As a result, it can develop through the learning process. It has a close relationship with the level of intelligence or quotient that students have. Expressions of the mind, ways of speaking, how to ask questions, and problem-solving skills reflect a person's intelligence. Intelligence as intellectual ability is a strong predictor of achieving learning outcomes or academic achievement. The essence of intelligence is the ability or general human skills in completing tasks in his life. Intelligence includes many mental abilities, such as the ability to learn, think abstractly, plan, understand ideas, solve problems. Keep in mind that intelligence is not the only determinant of academic achievement [9-12].

Another factor that needs to be considered in developing logical thinking abilities through learning mathematics is mathematical disposition. Disposition as a character carries a person to a particular experience and to make certain choices. Dispositions are guided by self-confidence and attitudes related to values. Mathematical disposition is as attitude, judgment, and interest in mathematics. Mathematical disposition means the tendency to think and act in a positive way of learning mathematics. This tendency is reflected in students' interests and beliefs in learning mathematics, the willingness to reflect on their own and trying to explore in solving mathematical problems. Students will find it complicated to get good achievements in learning mathematics if their attitudes or dispositions toward mathematics are not good [13-17].

The internal factor of students who play a role and affect the activities and learning outcomes is self-regulated learning. [18] states self-regulated learning is one of the soft mathematics skills as a component of mathematical thinking processes in the affective domain. Self-regulated learning is an active constructive process carried out by students. Students have an awareness of independently setting their learning goals, then trying to
control, monitor, and regulate cognition, attitudes, and motivation in learning. Self-regulated learning emphasizes the importance of personal responsibility in learning and controlling the knowledge or skills acquired. Organizing yourself in learning also bears students to be able to learn independently or become experts to master what they learn. [19-23] [24] explains one of the weaknesses of students in learning mathematics is just trying to memorize formulas. They tend to use formulas in solving problems and do not try to think what should be done first, so they do not have the ability to see the relationship between the concepts they already have. The development of logical thinking abilities through problem-solving in learning mathematics becomes not optimal, because of the learning experiences that have been possessed as if they were separated from one another.

2. Research Method

The research method used is a survey method with path analysis techniques. Logical thinking ability (Y) as an endogenous variable and exogenous variables are intelligence quotient (X1), mathematical disposition (X2), and self-regulated learning (X3).

The sample was taken by 355 students from 11 schools. To collect Intelligence quotient and logical thinking ability data, a test technique is used. Self-regulated learning and mathematical disposition use questionnaires. Before testing hypotheses, testing the analysis requirements first which includes the estimated error normality test, linearity test and the significance of simple regression between the two variables. Hypothesis testing is done using the Lisrel program.

3. Results and Discussion

The path coefficient analysis model of the above structure model is expressed in the equation  

\[ Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon \]

From the calculation results, the equation  

\[ Y = 0.37X_1 + 0.20X_2 + 0.23X_3 + 0.46 \]

The complete test results are explained through the path of the influence of X1, X2, and X3 on Y as follows.

1) Based on the calculation of path coefficients obtained \( \beta_1 = 0.37 \) with \( t_{value} = 7.01 \) and \( t_{table} (\alpha = 0.05) = 1.96 \). It is known that \( t_{value} > t_{table} \) then \( H_0 \) is rejected and accept \( H_1 \), which means there is a positive direct effect of Intelligence Quotient (X1) on logical thinking ability (Y).

2) Based on the calculation of path coefficients obtained \( \beta_2 = 0.20 \) with \( t_{value} = 2.39 \) and \( t_{table} (\alpha = 0.05) = 1.96 \). It is known that \( t_{value} > t_{table} \) then \( H_0 \) is rejected and accept
H_1, which means there is a positive direct effect of mathematical disposition (X_2) on logical thinking ability (Y).

3) Based on the calculation of path coefficients obtained \(b_{23} = 0.23\) with \(t_{\text{value}} = 2.70\) and \(t_{\text{table}} (\alpha = 0.05) = 1.96\). It is known that \(t_{\text{value}} > t_{\text{table}}\) then \(H_0\) is rejected and accepted \(H_1\), which means there is a positive direct effect of self-regulated learning (X_3) on logical thinking ability (Y).

3.1 The Effect of Intelligence Quotient on Logical Thinking Ability

The results of the study show that Intelligence Quotient has a positive direct effect on logical thinking abilities. Thus the high and low logical thinking abilities can be explained by Intelligence Quotient. The direct influence coefficient of Intelligence Quotient on logical thinking abilities is 0.37.

Intelligence quotient has an effect to the logical thinking ability because in the intelligence quotient there is the ability or capacity to think logically that can be utilized in learning. This finding is reinforced by the explanation of [25], that in the intelligence quotient there is fluid intelligence which is the ability to resolve and think logically about the problems that are currently experienced, free from the knowledge previously understood. Fluid intelligence reflects individual abilities in abstract thinking and understanding. In contrast to crystallized intelligence which is very dependent on prior knowledge and educational/academic achievements. Fluid intelligence is the process of analyzing current problems, identifying patterns and relationships implied by a problem and using calculations or logical thinking.

Intelligence quotient has a direct effect on logical thinking abilities because logical thinking ability is a reasoning ability that emphasizes the ability to use the knowledge that has been possessed to find logical alternative answers to various problems. While the intelligence quotient level of a person represents his intelligence in thinking. Behavior characteristics that have been indirectly agreed upon as a sign of having high intelligence, among others, are the ability to understand and resolve mental problems quickly, ability to remember, high creativity, and a developing imagination.

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The intelligence quotient level has a direct effect on logical thinking abilities. This is because logical thinking is a logic activity that requires intelligence. Explained by [8], that logic is a mental activity. It is done in phases and is a regular activity. The stages of the logic process begin with the formation of understanding, opinion formation, and conclusion drawing. Logically, as a process of logical thinking, it will be difficult if you don't have intelligence. So logical thinking is a product of intelligence. It has been described above that logical thinking ability as a reasoning ability, then logical thinking ability is a capacity that has been owned. This capacity can be potential from what has been owned as a default factor, and can also be influenced by various factors such as knowledge that has been possessed as a result of the learning experience.
3.2 The Effect of Mathematical Disposition on Logical Thinking Ability

The results of the study show that mathematical disposition has a positive direct effect on logical thinking abilities. Thus the high and low logical thinking ability can be explained by mathematical disposition. The direct effect coefficient of mathematical disposition on logical thinking abilities is 0.20.

The results of the study above explain that the better the disposition towards mathematics the better the logical thinking ability. A person who has a good mathematical disposition will show a persistent and diligent attitude in developing thoughts. The ability to reason, think logically will develop if the mathematical disposition continues to be sharpened and developed in the process of learning mathematics. This is in accordance with the learning objectives of mathematics, which emphasizes logical thinking abilities. Conversely, the more he has a logical thinking ability will be more interested in mathematics or increase his mathematical disposition. The results of this study are reinforced by the results of the study of [26] which states that there is a correlation between logical thinking abilities and mathematical disposition.

The role of mathematical disposition that can directly give the effect logical thinking abilities due to mathematical disposition has indicators: self-efficacy in using mathematics, solving problems, giving reasons and communicating ideas; flexibility in investigating mathematical ideas and trying to find alternative methods of solving problems; diligent and persistent working on mathematical tasks; interest, curiosity, passion, and meeting power in carrying out mathematical tasks; tend to monitor, think metacognitive, and reflect on their own reasoning; assess the application of mathematics to other situations in mathematics and everyday experience; appreciation of the role of mathematics in culture and value, mathematics as a tool, and as a language; and share opinions with others.

Based on the explanation above, it explains that the better the mathematical disposition of students, the better the logical thinking ability. This explanation is more supported by mathematical characters which are abstract basic object knowledge, which is based on the truth of consistency, arranged hierarchically and in accordance with the rules of logical reasoning. Mathematics can also be seen as a structure of relationships that connect symbols. [2]. This is also because mathematics is formed as a result of human thought related to ideas, processes, and reasoning. Thus learning mathematics not only learns concepts, procedures, and applications of mathematics but also includes developing mathematical disposition and appreciating mathematics as a tool that is powerful enough to think logically and solve problems.

3.3 The Effect of Self-Regulated Learning on Logical Thinking Ability

The results of the study show that learning independence has a positive direct effect on logical thinking abilities. It means that high and low logical thinking abilities can be explained by learning independence. The direct effect coefficient of learning independence on the logical thinking ability is 0.23.

Logical thinking ability is influenced by the independence of learning, because logical thinking ability is not only influenced by the potential factors already possessed, it is also influenced by the knowledge that has been possessed as a result of learning experiences. Learning is the process of changing behavior. An easily observable behavior is the ability to think as a cognitive ability, starting from knowing, understanding, and the ability to apply the knowledge that has been possessed, analyzing, synthesizing, and evaluating. With a simple sentence that thinking ability is influenced by learning outcomes as a result of the learning experience. Learning requires independence as a form of a sense of responsibility to regulate and try to achieve the expected learning outcomes.
This opinion is reinforced by the explanation that learning independence requires personal responsibility in achieving knowledge and skills that will be achieved in learning. Self-regulation in learning will have the effect of making students are able to master what they learn. [19].

Independence in learning will have an impact on the ability to think logically, the ability to solve problems in various forms of settlement, not easily influenced, dare to make their own decisions and not depend on others. Thus learning independence has a direct influence on logical thinking abilities. This is an important concern, because of logical thinking ability as a basic competency that will be achieved in mathematics learning. Logical thinking ability is one of the basic competencies that will be achieved in addition to understanding, communication and problem-solving.

The effect of learning independence on logical thinking abilities, supported or reinforced by the explanation that the ability and willingness to learn is the key to the development of one's thinking ability. The ability to think will develop if students are given a situation or problem, and try to find, ask, examine and try to find their own solutions to the problems given. Independence of learning is related to motivation where the process is supported by activities to achieve goals. [12].

4. Conclusion
Based on the results of the research and discussion above, it can be concluded that: 1) there is a positive direct effect of intelligence quotient on logical thinking ability, 2) there is a positive direct effect of self-regulated learning on geometric problem-solving abilities, 3) there is a positive direct mathematical disposition influence on logical thinking ability.

The results of this study have implications if the teacher wants to develop students' abilities in logical thinking, so in mathematics learning the teacher should pay attention to the characteristics of students, such as their intelligence, and try to develop positive attitudes or dispositions towards mathematics and student self-regulated learning.

5. References
[1] Nasution 2004 Berbagai Pendekatan dalam Proses Belajar dan Mengajar. (Jakarta: Bumi Aksara)
[2] Retnowati, Heri 2009 Pengaruh Kemampuan Awal dan Logical thinking ability/Penalaran terhadap Kemampuan Matematika (Studi Komparasi Sensitivitas Program Lisrel 8.51 dan Amos 6.0). Prosding Seminar Nasional FMIPA Universitas Negeri Yogyakarta
[3] Zenzan, Nazan, & A Bulbui 2011 A Scale of Logical Thinking Abilities. Procedia Social and Behavioral Sciences. 15 1
[4] Maksum, Ali 2016 Pengantar Filsafat Dari Masa Klasik Hingga Postmeodernisme. (Yogyakarta: Ar-Ruzz Media)
[5] Suriasumantri, Jujun S 2017 Filsafat Ilmu Sebuah Pengantar Populer. (Jakarta: Pustaka Sinar Harapan.)
[6] Sumarmo, Utari et al 2012 Kemampuan dan Disposisi Berpikir Logis, Kritis, dan Kreatif Matematika. Jurnal Pengajaran MIPA. 17 1
[7] Mundiri. Logika 2015 (Jakarta: Rajawali Pers)
[8] Heryadi, Dedi. 2017 Menumbuhkan Karakter Akademik dalam Perkuliahan Berbasis Logika. Jurnal Pendidikan Karakter. 7 1
[9] Fudyartanta, Ki. 2004 Tes Bakat dan Perskalaan Kecerdasan. (Yogyakarta: Pustaka Pelajar)
[11] Legg, Shane, & M Hutter 2007 A Collection of Definitions of Intelligence. *Frontiers in Artificial Intelligence and Applications*. 157 17

[12] Veas, Alejandro, R Gilar, & P Minano. 2016 The Influence of Gender, Intellectual Ability, Academic Self-Concept, Self-Regulation, Learning Strategies, Popularity and Parent Involvement in Early Adolescence. *International Journal of Information and Education Technology*. 6 8

[13] Anku, S Enyonam. 1996 Fostering Students’ Disposition towards Mathematics: A Case from a Canadian University. *Academic Journal Article Education*. 116 4

[14] Damon, W. 2005 Personality Test: The Dispositional Dispute in Teacher Preparation Today, and What to do About it. *Fwd: Arresting Insights in Education at Stanford University*. 2 3

[15] Atallah, Fida., S L Bryant & R Dada. 2010 A research framework for studying conceptions and dispositions of mathematics: A dialogue to help students learn. *Research in Higher Education Journal*, Academic and Business Research Institute. 7 1

7. [16] Moenikia, Mahdi, dan A Z Babelan 2010 A Study of Simple and Multiple Relations between Mathematics Attitude, Academic Motivation and Intelligence Quotient in Mathematics Achievement. *Procedia Social and Behavioral Science*. 2 1

[17] Feldhaus, C. Adam. 2012 How Mathematical Disposition and Intellectual Development Influence Teacher Candidates’ Mathematical Knowledge for Teaching in a Mathematics Course for Elementary School Teachers. *Dissertation* The Faculty of The Patton College of Education of Ohio University

[18] Sumarmo, Utari. 2014 Pengembangan Hard Skill Dan Soft Skill Matematik Bagi Guru dan Siswa Untuk Mendukung Implementasi Kurikulum 2013. *Prosiding Seminar Nasional Pendidikan Matematika Program Pascasarjana STKIP Siliwangi Bandung*

[19] Zimmerman, B.J. 1990 Self Regulated Learning And Academic Achievement: An Overview. *Educational Psychologist*, 25 1

[20] Schunk, Dale H. 2005 Self-Regulated Learning: The Educational Legacy of Paul R. Pintrich. *Educational Psychologist*. Lawrence Erlbaum Associates. 40 2

[21] Tirtarahadja, Umar, & La Sulo 2005 *Pengantar Pendidikan*. (Jakarta: Rineka Cipta)

[22] Valle, Antonio et al. 2008 Self-Regulated Profiles and Academic Achievement. *Psicothema*, 20 4

[23] Yildizli, Hulya, dan Ahmed Saban 2016 The Effect of Self-Regulated Learning on Sixth-Grade Turkish Students’ Mathematics Achievements and Motivational Beliefs. *Cogent Education*, 3 1

[24] Saragih, Sehatta 2013 Application of Generative Learning in Cooperative Settings TPS Type on Learning Areas and Space Analytic Geometry. *Jurnal Pendidikan Matematika Paradikma*. 6 1

[25] Huepe, David et al. 2011 Fluid Intelligence and Psychosocial Outcome: From Logical Problem Solving to Social Adaptation. *PloS ONE*. 6 9

[26] Rohaeti, Euis E., Budiyanto A.M dan Utari Sumarmo. 2014 Enhancing Students Mathematical Logical Thinking Ability and Self Regulated Learning through Problem Based Learning. *International Journal of Education*. 8 1