The Relationship between Logical-Thinking Ability and Science Achievement of Middle School Students

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Abstract. The students' science achievement is one of the educational problems that need to be considered. Factors that can influence students' science achievement are important to investigate in order to design science learning that is appropriate to students' characteristics in order to support the improvement of students' science achievement. Therefore, this study aims to identify the relationship between logical-thinking ability and students' science achievement. Sampling is done by using a random sampling technique. The sample used in this study were 33 middle school students grade VIII. The research data was collected using tests and observations, which were then analyzed using quantitative descriptive techniques with SPSS 21. The results obtained Pearson correlation values is 0.266 and significance value is 0.135 (Sig.> 0.05), which means that there is an insignificant relationship between logical-thinking ability and students' science achievement.

1. Introduction

There are three skills that each individual must possess in the 21st century, namely: a) learning skills and innovation; b) information, media and technology skills; and c) life and career skills [16]. The demands of the 21st century lead to education reform in Indonesia regarding changes in pedagogy, namely classical teaching changes that emphasize Low Order Thinking Skills (LOTS) became learning that emphasizes High Order Thinking Skills (HOTS) [4]. King et al., explain the ability that includes in the High Order Thinking Skills (HOTS), namely critical-thinking ability, logical-thinking, reflective-thinking, metacognition, and creative thinking [3].

Science is one of the subjects at the middle school level and one of the subjects tested in national exams. The fact is that student science learning achievements in Indonesia show a continuous decline. This can be seen from the average national examination of Natural Sciences in the last three years. The average of science achievement in national exams is presented in Table 1.

| Academic year | The average of science achievement |
|---------------|-----------------------------------|
| 2014 / 2015   | 59.88                             |
| 2015 / 2016   | 56.26                             |
| 2016 / 2017   | 52.19                             |

(Source: kemendikbud.go.id)
Table 1 explains that there has been a decrease in the national exam average in science subjects for the last three years. These results indicate that student science achievement in Indonesia is one of an educational problem that needs more attention. The excretion system is one of the materials in science subjects. The characteristic concept of an abstract and invisible excretory system requires the ability of students to be able to visualize it logically. Chimer states that science learning that involves physiological events that cannot be observed by naked eye makes it difficult for students to understand it [2]. In this regard, the results of observations on the daily evaluation of students in one of Surakarta's middle schools showed that in the excretory system material there were as many as 41% of students who had not reached the minimum completeness criteria.

Given the importance of attention to these problems, it is necessary to find a problem-solving solution. The solution that can be done is to identify factors related to students' science achievement, one of them is the ability to think logically. Logical-thinking ability takes a role in connecting the science concept with students' knowledge and experience so that students are able to solve complex problems [9][10].

There are some experts' opinions that define logical-thinking ability. Tobin & Capie assessed logical-thinking ability through Test of Logical Thinking (TOLT) that included five components: controlling variables, proportional reasoning, probabilistic reasoning, correlational reasoning, and combinatorial reasoning [15]. The next expert defines logical-thinking ability as the ability to estimate probabilities, correlations, combinatorial calculations, and analogies in order to analyse, classify, prove, and synthesise a case [17]. Stevens also stated that logical-thinking ability is one's ability to sort, compare, contrast, evaluate, and select to solve a problem [13].

Based on the knowledge of the factors related to the science achievement, the teacher can design science learning and assessment systems that are in accordance with the characteristics of students to support the improvement of students' scientific achievements. Therefore, the authors are interested in conducting research on the relationship between the logical-thinking ability and science achievement of middle school students in Surakarta.

2. Research Methods

2.1 Research design and samples
This study was conducted in one of the junior high schools in Surakarta, on the even semester, in academic year 2017/2018. This research is a quantitative descriptive research. This type of research is conducted to investigate the relationship between two or more variables, without making changes, additions or data manipulation [1]. The samples of this study were selected by applying a simple random sampling technique. This technique was used because there was no level in the research population, and the samples were selected randomly from the class where the research was conducted [14]. The number of samples in this study was 34 middle school students grade VIII.

2.2 Technique of data collection
The data in this study were collected using tests and observations. The tests are carried out to measure students' logical thinking ability and science achievement, while observations are carried out to get the information about science teachers' learning tools as supporting data.

Students are given a test of logical-thinking ability that has been tested for its validity and reliability before science learning is carried out. This test is given with the aim of categorizing the students' logical-thinking ability. The instrument of logical-thinking ability test consisted of 20 multiple choice questions with five alternative answer options. This test instrument is based on five indicators of logical-thinking ability according to Stevens, namely: 1) ordering, the ability to determine the order of an object based on nature; 2) comparing, the ability to compare the properties of similarities and differences in an object; 3) contrasting, the ability to group into similar traits; 4) evaluating, the ability to complete logical statements; and 5) selecting, the ability to draw induction or deduction conclusions [13].
The natural sciences learning on the topic of the excretion system is held three times. The excretory system in the skin organs is discussed at the first meeting, then the excretion system in the kidney organs at the second meeting, after that the excretion system in the lungs and liver did in the third meeting. After the learning process is complete, students are given tests that measure students’ science achievement in the excretory system. The instrument of science learning achievement that used in this study amounted to 20 multiple choice questions with five alternative answer choices. The instrument of students' science achievement has been validated of its content with two experts.

2.3 Data analysis technique
The data on the students’ logical-thinking ability are given before science learning about the excretion. Furthermore, the test of the students’ science achievement are given after science learning about the excretion system has completed. Then, the data on the logical-thinking ability and the science achievement are collected for analysis.

The data analysis was carried out with descriptive and inferential analysis techniques. The descriptive analysis techniques were done to know the big picture of data descriptively such as mean, standard deviation, and the number of students. Furthermore, inferential data analysis begins with testing the prerequisites in the form of a normality test and homogeneity test. Data normality test is done by Lilliefors technique using SPSS 21. Data homogeneity test is done by Levene test using SPSS 21. If the results of the prerequisite test indicate that the data is normally distributed and homogeneous, then a correlation test was done between logical-thinking ability and science achievement.

3. Results and Discussion
3.1 The Students’ Logical-Thinking Ability
The data on students' logical-thinking ability is obtained before science learning is conducted. The score of logical-thinking ability is divided into three categories according to Olivia, namely: 1) 0 - 30 (low); 2) 40 - 70 (moderate); and 3) 80-100 (high) [7]. The description of students' logical-thinking ability data is presented in Table 2 and Figure 1.

Table 2 showed that there are 30 students who have a moderate logical-thinking ability, while in the low category of logical-thinking ability there are 3 students. Table 2 also showed that there are no students who have high-level logical thinking skills. Based on Figure 1, it showed that the average result of the logical thinking ability obtained by the moderate level students is 49.33 while at the low level students is 31.67. The deviation score between students who have moderate logical-thinking ability and low logical-thinking ability is 17.66.

| Logical-Thinking Ability | Moderate | Low |
|---------------------------|----------|-----|
| Number of Students        | 30       | 3   |
| Mean                      | 49.33    | 31.67 |
| Standard Deviation        | 7.96     | 2.89 |
| The Highest Score         | 65       | 35  |
| The Lowest Score          | 40       | 30  |
Figure 1. Histogram of mean score comparison at the categories of logical-thinking ability

Based on the results of the analysis of the learning tools used by the science teacher, it is known that the learning settings are still classical. The activities of students test their logical-thinking has not taken place in the learning process. Pamungkas & Setiani stated that one of the learning criteria that is able to optimize logical-thinking ability is that there are activities where students test their logical thinking to obtain the relationship between these phenomena and their daily lives [8].

Based on the results of the analysis of the daily evaluation questions, it is known that the questions used by the teacher 70% are questions of type C1, 20% type C2, and 10% type C3. This showed that students have not been trained enough to work on high-level questions that require high-level thinking skills, one of them is the ability to think logically. Sezen stated that the ability to think logically is needed for someone to be able to solve complex problems [12].

3.2 The Students’ Science Achievements Based on Logical-Thinking Ability
Students' science achievement was obtained from students' cognitive tests on the excretion system material. The tests of science achievement are given after science learning about the excretion system has completed. The description of students' achievement data in the excretory system based on logical thinking skills is presented in Table 3 and Figure 2.

Table 3. The data on students' achievement in the excretory system based on logical thinking skills

| Science Achievements | Moderate Level of Logical-Thinking Ability | Low Level of Logical-Thinking Ability |
|----------------------|-------------------------------------------|---------------------------------------|
| Number of Students   | 30                                        | 3                                     |
| Mean                 | 61.44                                     | 45.55                                 |
| Standard Deviation   | 11.77                                     | 3.85                                  |
| The Highest Score    | 85                                         | 50                                     |
| The Lowest Score     | 40                                         | 45                                     |
Based on Table 3 it is known that the average of students' science achievement with moderate logical thinking ability is 61.44, while for students with a low logical-thinking ability is 45.55. These results indicated that the average students' science achievement with moderate logical thinking ability was better than the students who have a low logical-thinking ability. Figure 2 also showed that the deviation score between students who have moderate logical-thinking ability and low logical-thinking ability is 15.86.

In line with this, research conducted by Nnorom stated that students who have high reasoning ability obtained an average achievement of biological sciences that is greater than students who have low reasoning ability [6]. The results of research conducted by Yenilmez et al., also showed that there were significant differences between students with high and low levels of reasoning [18].

3.3 The Relationship between Logical-Thinking Ability and Science Achievements

The prerequisite test, the normality test and the homogeneity test, performed before conducting the inferential analysis. The prerequisite test was carried out on students' logical-thinking ability and science achievement using SPSS 21. The normality test used to find out whether the data were normally distributed or not. The data can be concluded normal if the significance value obtained higher than 0.05. The results of normality tests are presented in Table 4.

| Logical-Thinking Ability | Science Achievements |
|--------------------------|----------------------|
| 0.109                    | 0.142                |
| 34                       | 34                   |
| 0.200*                   | 0.078                |

*a. Lilliefors Significance Correction

* This is a lower bound of the true significance.
The normality test used in this study is the Lilliefors test using Kolmogorov-Smirnov. Based on Table 4, the normality test of students' logical-thinking ability data was obtained a significant value is 0.200, while in the students' science achievement data was 0.078. The results of these calculations indicated that the significance value obtained higher than 0.05. Thus it can be concluded that the data is normally distributed.

The homogeneity test in this research was done by using Levene test. The homogeneity test used to find out whether the data were homogeneous or not. The data can be concluded homogenous if the significance value obtained higher than 0.05. The results of homogeneity tests are presented in Table 5.

| Table 5. The results of homogeneity tests |
|-----------------------------------------|
| Levene Statistic | df1 | df2 | Sig |
|------------------|-----|-----|-----|
| Logical-Thinking Ability | 3.496 | 1 | 31 | 0.071 |
| Science Achievements | 3.646 | 1 | 31 | 0.066 |

Based on Table 5, the homogeneity test of students' logical-thinking ability data was obtained a significant value is 0.071, while in the students' science achievement data was 0.066. The results of these calculations indicated that the significance value obtained higher than 0.05. Thus it can be concluded that the data is normally distributed and can be continued with inferential analysis.

An inferential analysis is carried out using Pearson's correlation test with SPSS 21 at a significance level of 5%. This correlation test is used to determine the relationship between logical-thinking ability and students' science achievement. H₀ was accepted if the significance value lower than 0.05. The result of the correlation test is presented in Table 6.

| Table 6. The correlation between logical-thinking ability and students’ science achievements |
|-----------------------------------------------|
| | Science Achievements | Logical-Thinking Ability |
| Science Achievements | Pearson Correlation | 1 | 0.266 |
| Sig. (2-tailed) | | 0.135 |
| N | 33 | 33 |
| Logical-Thinking Ability | Pearson Correlation | 0.266 | 1 |
| Sig. (2-tailed) | | 0.135 |
| N | 33 | 33 |

Based on Table 6, the results of the Pearson correlation test using SPSS 21 obtained the correlation value is 0.266 and the significance value is 0.135. Table 5 also showed that the significant value between logical-thinking ability and science achievement is higher than 0.05 (0.135 > 0.05), which means that there was an insignificant relationship between the two variables.

The results of research conducted by Mirna explained that the ability to think logically has no direct significant effect on science achievement [5]. Further explained that the ability to think logically does not have a significant influence on student participation in the learning process. There are different research results regarding the relationship between students' logical-thinking ability and
science achievement. Sadi & Carikoglu conducted a study whose results showed that the ability to think logically had a significant influence on students' science achievement [11].

4. Conclusion
Based on the results of data analysis can be drawn several conclusions, such as: 1) Most of the students grade VIII in State Junior High School Surakarta have moderate logical thinking ability with an average of 49.33; 2) the average students' science achievement with moderate logical thinking ability was better than the students who have a low logical-thinking ability that was 61.44 > 45.55; and 3) there is an insignificant relationship between logical-thinking ability and students’ science achievement with a significance value 0.135 (Sign. > 0.05).

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