Students’ logical-mathematical intelligence profile

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Abstract. One of students’ characteristics which play an important role in learning mathematics is logical-mathematical intelligence. This present study aims to identify profile of students' logical-mathematical intelligence in general and specifically in each indicator. It is also analyzed and described based on students’ sex. This research used qualitative method with case study strategy. The subjects involve 29 students of 9th grade that were selected by purposive sampling. Data in this research involve students’ logical-mathematical intelligence result and interview. The results show that students' logical-mathematical intelligence was identified in the moderate level with the average score is 11.17 and 51.7% students in the range of the level. In addition, the level of both male and female students are also mostly in the moderate level. On the other hand, both male and female students’ logical-mathematical intelligence is strongly influenced by the indicator of ability to classify and understand patterns and relationships. Furthermore, the ability of comparison is the weakest indicator. It seems that students’ logical-mathematical intelligence is still not optimal because more than 50% students are identified in moderate and low level. Therefore, teachers need to design a lesson that can improve students' logical-mathematical intelligence level, both in general and on each indicator.

1. Introduction

Gardner thinks that intelligence as a biological factor that depends on the environment, the culture, the community around, and with whom he/she interacts [1]. Gardner also defined intelligence as “a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture” [2]. Gardner & Hatch stated that intelligence is traditionally defined in terms of Intelligence Quotient (IQ), which measures the range of simple Verbal/Linguistic and Logic/Mathematical abilities [3]. Furthermore, Gardner’s statement regarding the theory of multiple intelligences gives the dimension where each individual is different from the others. It means that in the learning process every student has different abilities and characteristic, including their intelligence. This intelligence profile can influence the learning process and learning outcomes [1]. Therefore, it is necessary for the teachers to know the characteristics of multiple intelligences of students to choose strategies that can improve the effectiveness of learning process in the classroom, include mathematics learning.

The purpose of teaching and learning of mathematics is not only the students have good knowledge of numerical facts, but also problem-solving skills that can be adapted according to the strengths and weaknesses of each student [4]. In Indonesia, one of the benchmarks to monitor, to encourage and to improve the quality of learning in the classroom is national exam results. Based on the results of mathematics national examination in SMP Al-Irsyad Surakarta shows that student achievement has not
optimal yet. Based on Table 1 shows that the average value of mathematics subjects is still below 50 points despite there was an increase of the average value from 2016 to 2017 [5, 6, 7].

| Year | SMP Al-Irsyad (%) | Central Java (%) | National (%) |
|------|------------------|------------------|--------------|
| 2015 | 42.71            | 47.43            | 56.28        |
| 2016 | 39.75            | 43.39            | 50.24        |
| 2017 | 47.16            | 48.65            | 50.31        |

Source: Badan Standar Nasional Pendidikan (BSNP)

The low result of mathematics learning is influenced by several factors. Multiple intelligence is one of the factors that influence the capability of students in mathematics. It cannot be separated from the various theoretical and empirical studies that found a positive relationship between the multiple intelligences and students' mathematics learning achievement [8, 9]. Learning achievement is a strong indicator that explains the students who succeed in learning process in the classroom, it is very important to pay attention to the student's characteristics of intelligence and so that we can improve the achievement of students with moderate intelligence level and low intelligence level. It can make the students know about their strengths and weaknesses [10].

One of the multiple intelligences that a role in mathematics learning is logical-mathematical intelligence. A student with well-developed logical-mathematical intelligence will be able to observe and recognize the patterns and relationships [11]. It means that students’ logical-mathematical intelligence plays a huge role in problem-solving activities. Someone who is able to solve math problems is the person that has good logical-mathematical intelligence [12]. In another case, to solve the problems of mathematics is required the component of logical-mathematical intelligence (ability to finding and reasoning) [13]. The results of Rahbarnia, et al. [14] also showed that there is a positive correlation between logical-mathematical intelligence and mathematical problem solving.

Gardner described logical-mathematical intelligence as the ability to study the problems, complete the logical and analytical, mathematical operations, and conduct scientific investigations [15]. Logical-mathematical intelligence can also be interpreted as “an individual's sensitivity to, and capacity to discern, logical or numerical patterns, and ability to handle long chains of reasoning. These individuals like to experiment, solve puzzles, and ask cosmic questions” [16]. Based on those opinions above, it seems that students' logical-mathematical intelligence includes several individual elements of ability such as the ability to classify, study and solve problems, make logical reasoning, and analytical thinking.

Saban explained that students with high level of logical-mathematical intelligence are more able to classify objects in several categories, identify logical relationships between events, and perform certain quantitative calculations to identify real relationships between events [17]. Onay argued, “logical-mathematical intelligence is a skill about thinking with numbers, calculation, deriving conclusions, constituting logical relationships, problem solving, critical thinking, introducing with abstract symbols like numbers, geometrical shapes, relating knowledge pieces” [18]. Meanwhile, Willis and Johnson revealed that logical-mathematical intelligence encompasses five core areas: (1) classifying; (2) comparing; (3) basic numerical operations; (4) inductive and deductive reasoning; and (5) making and testing hypothesis [19]. Thus, logical-mathematical intelligence is the ability of students to identify and classify objects, perform mathematical calculations, solve the problems, think logically and critically, and make conclusions. Based on the definition of logical-mathematical intelligence above it appears that students' logical-mathematical intelligence can be identified based on several indicators. Moreover, the level of logical-mathematical intelligence of students in this study can be identified and measured using a logical-mathematical intelligence test was developed based on the indicators presented in Table 2.
Another important issue is sex influences on educational outcomes. Several studies have been conducted to review the concepts of multiple intelligences and sex [20, 21]. Therefore, this study will find how the student's logical-mathematical characteristics specifically based on students’ sex.

Based on the explanation above, it seems that the characteristics of students’ multiple intelligences play an important role in the success of learning process. Specifically, this study focuses on the profile of students' logical-mathematical intelligence in mathematics learning. Several studies have been conducted to find the correlation between students' multiple intelligences and student achievement [22, 23, 24, 25]. However, there are a few studies that pay attention to students’ logical-mathematical intelligence profiles generally and specifically on each indicator. Most of the previous research just to look at the profile of multiple intelligences generally [1, 26, 27], or just to develop a valid instrument that can identify multiple intelligences [3, 28, 29] and also just to see how huge the impact of theoretical-based learning of multiple intelligences for student learning achievement was [10, 22, 30]. It is important for teachers to recognize the characteristics of students’ logical-mathematical intelligence to improve and develop the process of mathematics learning in the classroom. This is in accordance with the opinion of Emmiyatti, et al. [1] that teachers need to understand multiple profiles of students' multiple intelligences in order to provide appropriate learning activities in the classroom that accommodate multiple students' intelligence. Therefore, this study aims to identify students’ logical-mathematical intelligence profile. In particular, this study focuses on the analysis and description of logical-mathematical intelligence generally and specifically on each indicator, namely the ability to understand the patterns and relationships, classification, comparison, mathematical calculations, and deductive-inductive reasoning. In addition, logical-mathematical intelligence is analyzed and described based on students’ sex.

### Table 2. Logical-Mathematical Intelligence Indicators

| Indicator                              | Descriptions of Characteristics                                      |
|----------------------------------------|---------------------------------------------------------------------|
| Ability to understand patterns and relationship | Students are able to identify the patterns and relationships between several numbers or objects. |
| Ability to classify                     | Students are able to group the objects into several categories       |
| Ability to compare                     | Students are able to find the comparison between two object group    |
| Ability to do the mathematical calculation | Students are able to finish the calculation well                    |
| Ability to inductive and deductive reasoning | Students are able to make a conclusion from the information logically |

2. Method

This research is a type of descriptive analysis research using qualitative method and case study strategy. Qualitative research is a study to understand the phenomenon experienced by research subjects holistically through descriptions in the form of words [31]. Merriam stated the definition of a case study as “intensive and holistic description and analysis of limited phenomena such as a program, an institution, a person, a process, or a social unit” [32]. Thus, qualitative research with case study strategies is a study to explore and understand the subject and phenomenon intensively and holistically through the oral description. In this research, the phenomenon refers to students' logical-mathematical intelligence in general and specifically in each indicator.

This research was conducted at SMP Al Irsyad Surakarta, Indonesia from September until October 2017. Subjects in this research involved 29 students 9th grade selected by purposive sampling technique. The data in this research were the students’ logical-mathematical intelligence test results and interview recordings. The instrument of this research includes a logical-mathematical intelligence test and interview guidelines. Logical-mathematical intelligence test consists of 20 multiple choice questions developed by researchers based on several indicators, namely ability to understand patterns...
and relationships, classification, comparison, mathematical calculations, and deductive-inductive reasoning. Before using logical-mathematical intelligence test, the instrument was validated by four validation expert. In addition, researchers conducted a 30-point test instrument to measure grain difficulty, grain distinguishing and the reliability. The test results of the logical-mathematical intelligence test were imposed on 92 students showed the grain difficulty level of 0.3≤p≤0.7, the divergent power index D≥0.3 and the reliability coefficient r1 = 0.74.

Subjects were asked to complete a logical-mathematical intelligence test before being interviewed. The results of the logical-mathematical intelligence test and interview were analyzed qualitatively by using Miles and Huberman’s steps to describe the students’ logical-mathematical intelligence level [33]. Naderi studied Male Versus Female Intelligence Among Undergraduate Students: Does Gender Matter? [34]. Activities in data analysis include data reduction, data display, and verification. Firstly, researchers analyzed the results of logical-mathematical intelligence test consisting of 29 students to know the average and level of logical-mathematical intelligence of students. After that, some students were interviewed to investigate and explore students’ logical-mathematical intelligence. In this study, it focuses on the analysis and description of students' logical-mathematical intelligence in general and specifically in each indicator. In addition, logical-mathematical intelligence is analyzed and described based on students’ sex.

3. Result and Discussion

The result of this study represents the capability of student from logical-mathematical intelligence test and interview recorded. Logical-mathematical intelligence test result was described by Table 3 and classified into high level, moderate level, and low level. Table 3 also describes data frequency and percentage of students based on level of intelligence and students’ sex. On the other hand, Table 4 explains the average score of students and the percentage of each logical-mathematical intelligence indicator of male and female students.

Table 3 described that 15 students (51.7%) have moderate level of logical-mathematical intelligence with average score 11.17. Eight students (27.6%) have high level of logical-mathematical intelligence and only 6 students (20.7%) have low level of logical-mathematical intelligence. Based on students’ sex, both of male and female student have moderate level of logical-mathematical intelligence, 5 students (41.67%) for male and 10 students (58.82%) for female with average score of male students is higher than female students (11.42:11.00).

| Table 3. Description of Students’ Logical-mathematical Intelligence Test Result |
|-----------------------------------------------|
| **Group** | **Male** | **Female** | **TOTAL** |
|---------|--------|---------|---------|
| **Level LMI** |  |  | |
| High    | 4 |  33.33 | 4 | 23.53 | 8 | 27.6 |
| Moderate| 5 |  41.67 | 10 | 58.82 | 15 | 51.7 |
| Low     | 3 |  25   | 3 | 17.65 | 6 | 20.7 |

Based on the results, it appears that male students have higher logical-mathematical intelligence than female students. These results were supported by several other researchers who identified intelligence based on sex differences [34, 35]. Andrian & Buchanan's research on sex differences in 20 countries shows that males are significantly higher in outcomes than female for intelligence in general. Adrian and Buchanan state that these differences of intelligence are consistent across countries and populations, although there is little difference [20]. More specifically, in research conducted by Rammstedt and Rammsayer show that male students have higher logical-mathematical and spatial intelligence than female students [35].
Based on each indicator, Table 4 shows that logical-mathematical intelligence is strongly influenced by the student’s capability to classify and understand the patterns and the relationship. It can be seen that 25% of the total score of students in this study were influenced by the students’ classification ability with the average score of 2.79. In the second place, indicator of ability to understand the pattern and the relationship was 24% of the total score of students with average score of 2.72. The weakest indicator is ability to comparison (only 8.6% of the total student score with an average score of 0.97). Meanwhile, for indicator of ability to deductive-inductive reasoning was 22.5% of the total score of students with average score of 2.52 and indicator of ability to computing was 19.4% from the total score of students with the average score 2.17.

Table 4. Students’ Average Score and Percentage of Each Logical-mathematical Intelligence Indicator

| Indicator LMI                        | Male | Female | TOTAL |
|--------------------------------------|------|--------|-------|
| Understand patterns and relationships| 2.75 | 2.71   | 2.72  |
| Classification                       | 2.75 | 2.82   | 2.79  |
| Comparison                           | 1.25 | 0.76   | 0.97  |
| Calculation                          | 2.5  | 1.94   | 2.17  |
| Deductive-inductive reasoning        | 2.17 | 2.76   | 2.52  |
| TOTAL                                | 11.42| 11.00  | 11.17 |

Based on the students’ sex, the most influencing indicator of the logical-mathematical intelligence of male students from strongest to weakest is the ability to understand the patterns and the relationships, classification, computation, inductive-deductive reasoning and comparison. On the other side, for female students, indicators that influence the logical-mathematical intelligence from strongest to weakest are the ability of classification, inductive-deductive reasoning, understanding the patterns and the relationships, computation and comparison. Male students are stronger than female students in indicators of ability to understand the patterns and relationships, comparisons, and computations. While female students are stronger than male students in indicators of classification ability and inductive-deductive reasoning.

Based on the results of interviews with several students, it appears that major students did not experience significant difficulties in any points of problem questions from classification capability indicators and ability to understand patterns and relationships. Students look easy to understand the problem and find the right answer. This indicates that students’ logical-mathematical intelligence in general is strongly influenced by the ability of classification and the ability to understand patterns and relationships. Furthermore, for the item number of the comparison indicator, some students appear to be confused between the ratio of values with the reversed ratio. In addition, students look less thorough when performing mathematical calculations. The same thing happened to some point number about indicator of computation ability. Students said they were not interested in questions involving numbers and calculations. Some students said that the item number of the computational ability indicator is the last part done when performing a logical-mathematical intelligence test. As for the item number indicator of the ability to make inductive-deductive reasoning, some students said that confused determine the exact conclusion of the premises of the question.

These findings are supported by previous researchers who stated that students in the high, medium, low category can classify the information on the problem, be able to compare the relationship between
the existing information on the problem with the knowledge they possess, and capable of performing mathematical calculation operations. Meanwhile, for the ability to use inductive or deductive reasoning can only be done by students from high and moderate category [36]. Research conducted by Nofianti, et al. [37] also found that classification characteristics are characteristics with the highest percentage compared to other logical-mathematical intelligence characteristics.

4. Conclusion
Based on the results and discussion above, it can be concluded that most of students were moderate level in logical-mathematical intelligence (51.7% of students have an average score of 11.17). In addition, both of logical-mathematical intelligence level of male and female students was a moderate. The intelligence level of male and female student was strongly influenced by the capability to classify and understand the patterns and the relationships. Furthermore, the comparative ability was the weakest indicator. It seems that students' logical-mathematical intelligence had not been optimal yet because more than 50% of them had moderate-low level. Students' logical-mathematical intelligence point on certain indicators was still low. Therefore, teachers need to design a learning method that can improve students' logical-mathematical intelligence level generally and also in every single indicator. This can be solved by facilitating students in the process of learning mathematics by providing problem-solving questions in accordance with students' logical-mathematical intelligence indicators. In addition, there is a need for further efforts to develop valid and reliable instances for measuring logical-mathematical intelligence particularly. This will be useful for teachers to know the students' logical-mathematical intelligence profile and use it for evaluation of the learning method.

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