

## The Classification of Mathematical Literacy Ability in Cognitive Growth Learning Viewed from Multiple Intelligences

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### Abstract

This research aims to determine the quality of the Cognitive Growth mathematical learning model towards mathematical literacy ability and to describe the classification of mathematical literacy ability viewed from the theory of multiple intelligences. This descriptive qualitative study involved 30 eight-grade students with the inclination on each type of multiple intelligence as the research subjects. The data were collected through test, observation, and interviews. The research revealed the following points: (1) the quality of mathematical learning using the Cognitive Growth model was in the good category; (2) mathematical literacy ability in Cognitive Growth learning viewed from multiple intelligences theory can be classified into: verbal-linguistic, logical-mathematical, and fourth-level musical intelligences; third-level visual-spatial intelligences, second-level intrapersonal intelligences, and first-level bodily-kinesthetic, interpersonal, and naturalistic intelligences. Based on these results, this study concludes that the mathematical literacy on different topics compiled based on the indicators of mathematical literacy in cognitive growth learning model has been well improved.

**Keywords:** cognitive growth model, mathematical literacy ability, multiple intelligences theory

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### Introduction

In terms of national education, Law No. 20 of 2003 on National Education System, Article 3 states: "The National Education functions to develop the capability, character, and civilization of the nation for enhancing its intellectual capacity, and is aimed at developing learners' potentials so that they become persons imbued with human values who are faithful and pious to one and only God; who possess morals and noble character; who are healthy, knowledgeable, competent, creative, independent; and as citizens, are democratic and responsible." (Depdiknas, 2003). In addition, it is expected that the students can use mathematics as a way of reasoning (logical, critical, systematic, and objective ways of thinking). According to Gagne (1985), the indirect object of learning mathematics is that the students should have the ability to solve various problems. Gagne's opinion and the purpose of the curriculum on mathematics highlight that in order to solve a problem, the students need to have adequate reasoning abilities that can be obtained through learning mathematics.

The low quality of Indonesian Human Resources currently is due to the poor quality of education, especially related to Mathematics as seen from various indicators. At the national level, Mathematics learning in schools is evaluated through the Standard Computer-Based National Examination, while, at the international level, students' mathematical abilities are assessed by two methods of assessment: TIMSS (Trend in International Mathematics and Science Study) and PISA (Program for International Student Assessment).

In terms of Mathematics abilities, Indonesian students ranked 36<sup>th</sup> out of 40 countries in 2011 in the Trends in International Mathematics and Science Study (TIMSS), and in 2015 Indonesian students ranked 45<sup>th</sup> out of 50 countries with the score of 397 that is far below the international average score of 500.

The low quality of education can also be seen in the 2015 PISA report which ranked Indonesia 62<sup>nd</sup> for Science, 63<sup>rd</sup> for Mathematics, and 64<sup>th</sup> for Reading out of 70 countries (OECD, 2016). Similar performance can be seen in 2012 where Indonesia ranked 64<sup>th</sup> for Science and Mathematics and 61<sup>st</sup> for Reading out of 65 countries. The average scores for Science, Mathematics, and Reading was 403, 386, and 397 respectively in 2015, and 382, 375, and 397 in 2012.

Mathematics literacy is very important because it emphasizes the students' ability to analyze, reason and communicate ideas effectively about the mathematical problems they encounter (OECD, 2009). This is what connects mathematics studied in the classroom to various real-world situations. According to the OECD (2012), mathematics literacy is the ability to formulate, implement, and interpret mathematics in various contexts. In this case, it includes mathematics reasoning and uses mathematics concepts, procedures, facts and tools to describe, explain, and predict phenomena/events.

Based on observations of eighth grade students at the Ihsanul Fikri Islamic Junior High School in Magelang City, and SMP N 8 Magelang, it was evident that the questions given to students were still at the basic level. The teachers had not yet provided more varied questions, especially related to mathematical literacy. The students solved many standard problems without deep understanding. As a result, their mathematical literacy abilities and strategic competencies did not improve. This is supported by Rusmining, Waluya and Sugianto's research (2014) which advised mathematics teachers that they should begin to introduce students with problems related to mathematics literacy.

Many efforts have been made to improve the students' ability in terms of achieving better performance on the mathematics problem questions in PISA. Solving these problems not only emphasizes the scope of learning achievement, but also considers the students' psychology and characteristics as inseparable elements. The students' mathematics literacy skills can be viewed from various dimensions. The dimensions of individual differences include the ability to think logically, creativity, cognitively, and intelligently.

The theory Multiple Intelligences is a theoretical framework for defining, understanding, developing, and assessing different intelligences. The teachers apply this as a framework for teaching and learning in class. Learning mathematics is not a simple task. The teachers must try to be creative in the learning process (Gouws, 2007). The concept of multiple intelligences focuses on the aspects of uniqueness for each child. This fact is supported by Rafianti's research (2013) stating that improving the students' understanding of mathematics concepts and reasoning ability using multiple intelligence-based mathematics learning was better than those receiving conventional learning methods.

The learning quality must also be considered and one of the influential factors is the accuracy of the learning model. Based on the observations made on the mathematics teachers of grades VII and VIII at one of the junior high schools in Magelang, Central Java, Indonesia, most of teachers still use the basic learning models. They rarely used new models to help the students in learning, especially for learning geometry. Some teachers until now still teach using traditional methods, which emphasizes training or practice and procedural questions. Thus, the teachers function as the center or source of all the materials, which only gives the teacher a room to be active in the learning process, while treating students as the passive recipients of the material. This situation is one of the main causes of the low quality of students' understanding of mathematics (Ali & Jameel, 2016).

The Cognitive Growth Model is one of the learning methods that can improve the students' mathematic literacy abilities. According to Piaget in Joyce (1992), the Cognitive Growth Model aims at improving the students' thinking abilities (cognitive). It attempts to match the stage of learning development and improve the students' mathematic literacy abilities. The role of students in this model is to generate responses and ask for justification in

conveying the results in the learning process. Through this process, the teachers are also required to prepare the materials well and condition of the class so that learning activities are appropriate for the learning objectives. This encouraged the researcher to examine the quality of Cognitive Growth learning upon the students' mathematic literacy abilities and to classify the mathematic literacy abilities of eighth grade junior high school students. The syntax of cognitive growth learning refers to Joyce's opinion listed in the following Table 1.

Table 1  
*Syntax of Cognitive Growth Model*

Phase	Description
Phase 1 <i>Confrontation with stage-relevant tasks</i>	The integration of tasks/problems according to the stage, and the students' orientation on the problem to study; it is intended that students are ready to think more critically in the next learning phase.
Phase 2 <i>Inquiry</i>	Organizing the students to raise their sensitivity and improving their critical thinking ability, performing in group formation activities in a class. Analyzing and evaluating the process; the learning process that has been implemented is evaluated/reflected to improve the learning activities, while the results are criticized and discussed together in the class
Phase 3 <i>Transfer Phase</i>	The integration of tasks/problems according to the stage, and the students' orientation on the problem to study; it is intended that students are ready to think more critically in the next learning phase.

Based on the views of this syntax, the cognitive growth model fits in with the stages of learning development and improves mathematics literacy. This research aims to provide additional knowledge about learning mathematics, especially to improve mathematical literacy. Besides, it is also expected to provide inputs to the educators for more innovative learning using cognitive growth model.

The research mainly focuses to answer the following questions: (i) how does the quality of Cognitive Growth learning influence the students' mathematic literacy abilities?; and (ii) is the classification of mathematic literacy abilities of the eighth-grade students related to the multiple intelligences? Thus, the purpose of this study is to determine the quality of the Cognitive Growth model in the mathematics learning process compared with the students' mathematic literacy abilities, and to describe the students' mathematic literacy abilities in terms of the theory of multiple intelligences.

### Research Methods

This is a descriptive qualitative research on the quality of the cognitive growth learning model and the classification of the students' mathematics literacy ability of eight-grade students based on the multiple intelligences theory.

The research subjects were the eighth-grade students of junior high school in Magelang city and the research subjects were selected based on the results of multiple intelligences tests. Two students were selected for each level because the data were analyzed using constant comparative method, and the selection had a snowball effect in which the next subject was selected based on on the analysis of the previous subject. If there was no subject to occupy a particular level, the process was done repeatedly until one subject was selected.

This study used an interview as the main research instrument. The researcher carried out the interview based on the interview guidelines. To conduct the interview, the researcher

acted as a planner, data implementer and collector, analysers, data interpreter, and the reporter of the research results. Other instruments were in the form of mathematics literacy questions, interview guidelines, observation sheets, lesson plans and syllabus, and multiple intelligences tests.

### **PISA-based Mathematics Literacy Questions**

This study used the mathematics question sheet taken from the mathematics questions from the PISA criteria (OECD, 2013). The question sheet was in the form of word problems taken from realistic daily life problems. This instrument was validated by experts, consisting of four mathematical education experts/mathematicians; two lecturers of mathematics education of Semarang State University and two mathematics teachers in Magelang. Validation was done to find out that the use of language and construction of the questions was in accordance with the indicators. The assessment of the validators revealed that the question was in accordance with the formulation of the research problem in terms of the construction of the questions, the language of the questions, and the subject matter.

### **Interview Guideline**

The interview guidelines in this study contained a list of questions to be asked orally by the researcher to the students to uncover the students' literacy level based on the mathematics literacy indicators. These interview guidelines were validated by three experts, consisting of mathematics education experts. Some improvements were made to the interview guidelines during the validation process.

### **Mathematics Literacy-Based Learning Materials**

Learning materials were validated by three mathematics education experts by considering various aspects, namely: syllabus indicators; lesson plans that must be in accordance with the mathematics literacy competencies; and the learning objectives. The instruments were revised according to the validators' advice.

### **Multiple intelligences test**

The questionnaire used a Likert scale and was adopted and modified from a multiple intelligences measurement tool known as Roger's Indicators of Multiple Intelligences (RIMI) test. The questionnaire was modified to adjust to local conditions using easy-to-understand language for the respondents who were still at junior high school level. The multiple intelligences test was assessed based on the number of the students' correct answers on each item.

## **Results and Discussion**

### **Results of Multiple Intelligences Test**

The multiple intelligences test was aimed to determine the type of the students' intelligence and was used as a consideration in choosing the subjects to have an in-depth interview about the mathematics literacy ability. The multiple intelligences test was assisted by psychologists and accompanied by eight observers in each category of multiple intelligences. Based on multiple intelligences test results, the distribution of multiple intelligences of eight-grade students of class B can be seen in Table 2 below.

Table 2.

*Multiple Intelligences Classification of Eight-Grade Students of Class B*

Students' Category	Number of Students	Percentage
Verbal/linguistics	3	10.00 %
Logical Mathematics	4	13.33 %
Visual/Spatial	5	16.67 %
Kinesthetics	2	6.67 %
Musical	5	16.67 %
Interpersonal	4	13.33 %
Intrapersonal	4	13.33 %
Naturalists	3	10.00 %
Total	30	100.00 %

**The quality of mathematics learning using Cognitive Growth model on the achievement of mathematics literacy abilities**

The quality of mathematics learning using the Cognitive Growth model for mathematical literacy abilities was rated in the good category. The learning quality is classified as good if 3 minimum domains are met in the good category, namely planning and preparation, classroom management and organization, and assessment (Mac Gregor, 2007). The three domains can be specified as follows.

***Planning and preparation***

The measurement of the learning quality on the preparation stage is carried out using a validity test on the minimum device in the good category.

Table 3.

*Data Summary of Validation Test Results*

No.	Learning device	Score	Category
1.	Syllabus	3.070	Good
2.	Lesson plans	3.670	Very Good
3.	Students' worksheets	3.780	Very Good
4.	Students' jobsheets	3.580	Very Good
5.	Material supplement	3.625	Very Good
6.	Math literacy abilities test	3.580	Very Good
7.	Multiple Intelligence test	3.070	Good

***Classroom management and organization***

The learning management in the classroom had an average score of 3.93, which belongs to the good category. The results of the assessment of the learning outcomes obtained from the observation process are shown in Table 4.

Table 4.

*Results of Learning Organization Assessment*

No.	Learning Quality	Average Score	Category
1.	Observation 1	3.81	Good
2.	Observation 2	3.96	Good

3.	Observation 3	4.21	Very Good
	Average	3.99	Good

### Assessment

The assessment attempts to measure the achievement of the learning objectives and is obtained from the results of the Mathematics Literacy Ability Test (in Indonesian, *Tes Kemampuan Literasi Matematika*, abbreviated as TKLM) and the students' response to the questionnaire. The average score for the TKLM is 72.31 which belongs to the good category. The results of students' response analysis show that the percentage of students' positive responses to all aspects was higher than 50%, so more than 50% of the students gave a positive response toward the learning process.

### Classification of mathematics literacy abilities on Cognitive Growth learning viewed from Multiple Intelligence of the eight-grade students

Data of Mathematics Literacy Test from try-out 1, 2 and 3 is presented in Table 5.

Table 5.

#### Results of Mathematics Literacy Test

No.	Notes	TKLM 1	TKLM 2	TKLM 3
1	Average Score	60.39	76.54	80.01
2	Lowest Score	52.00	53.00	56.25
3	Highest Score	70.00	72.70	81.39
4	Number of level 1 students	21.00	10.00	8.00
5	Number of level 2 students	8.00	9.00	5.00
6	Number of level 3 students	1.00	8.00	5.00
7	Number of level 4 students	0.00	3.00	12.00
8	Number of level 5 students	0.00	0.00	0.00
9	Number of level 6 students	0.00	0.00	0.00

Table 4 portrays an increase in the average score of mathematics literacy ability, from 60.39 in TKLM 1 to 76.54 in the second trial, and to 80.01 in the third trial. There was an upsurge in the number of students in the three levels from TKLM 1 to TKLM 2, which decreased slightly between TKLM 2 and TKLM 3, and rose again since the students could successfully achieve level 4.

### Mathematics literacy abilities of verbal/linguistics type

Based on the results of TKLM, the verbal type students demonstrated diverse abilities on the math literacy questions of the written tests. From the results of the in-depth interviews, the average verbal/linguistic ability of students was scored at level 4 and was classified as good at level 4.

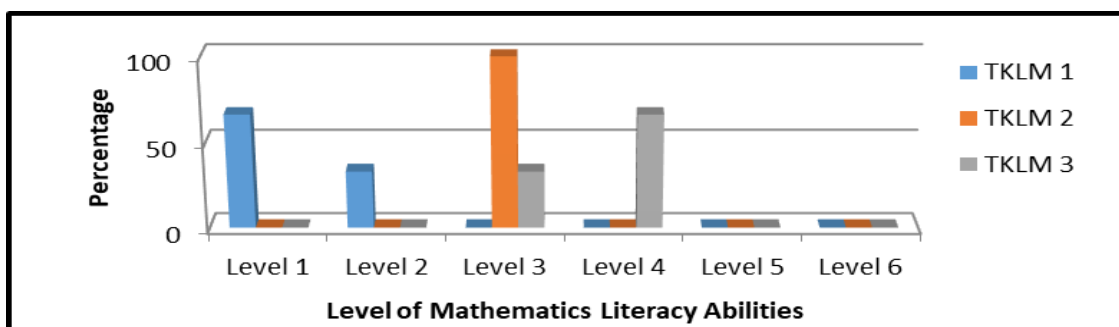


Figure 1. Level of mathematics literacy abilities of verbal/linguistic students.

The results indicate that the verbal/linguistic students' mathematical literacy abilities from the indicators of communication, mathematizing, representation, reasoning and argument, solving problems for devising strategies, using symbolic, formal and technical language and operations, using mathematics tools are at the good category (level 4). However, the verbal/linguistic students could not evaluate the solutions for the mathematics literacy problems, although their advantages were in solving mathematical literacy problems from indicators of communication and reasoning in the argument process as verbal students give more responses. During the interview they provided a complete description at level 4, even though the draft answers were not as complete as what the verbal type students convey. This result resonates with the finding from Mannamaa, et al. (2012), which stated that the students who have high verbal abilities are able to convey problems of mathematics stories.

#### Mathematics literacy abilities of logical-mathematical students

Based on the results of the TKLM, the logical-mathematical students showed homogeneous abilities on the written test. From the in-depth interviews, the average ability of the mathematics literacy was at level 4 and was classified as good at the level 4.

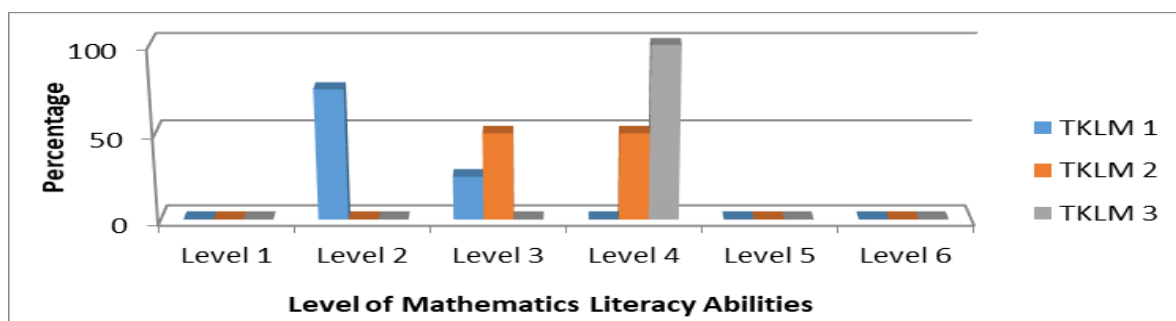


Figure 2. Level of mathematics literacy abilities of logical-mathematical students.

The mathematics literacy abilities of the logical-mathematical students on the indicators were classified as level 4. However, at level 5 they began to experience difficulties in the process of solving the literacy problems that had not been fully implemented and the representation had not been fulfilled. Thus, the logical-mathematical students' understanding at level 5 in the representation process were still low. This indicator corresponds with PISA result, which indicate that students at level 4 were able to work effectively using implied models in concrete situations, but had difficulties in facing obstacles or making assumptions.

### Mathematics literacy abilities of visual/spatial students

Based on the results of the TKLM, the visual-type students presented diverse abilities on the written test. From the results of the in-depth interviews, the average ability achievement of visual/spatial students was at level 3 and were classified as good at level 3.

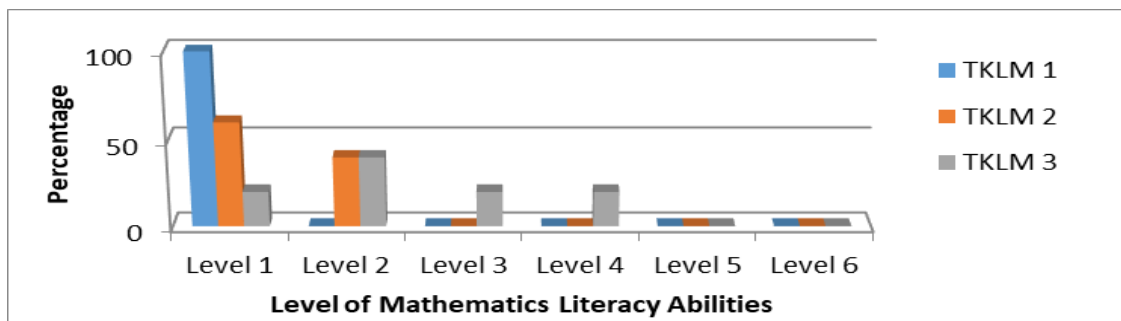


Figure 3. Level of mathematics literacy abilities of visual students.

The prominent aspect with the visual students lies in the images created. Spatial visual intelligence is the ability to visualize two or three-dimensional objects (images) to solve mathematical problems in daily life. From the interviews, the visual students revealed their preference of the pictorial literacy questions because these type of questions made them easier to find out information about the problem. This result is in line with the study by Ningsih (2014), which stated that students with visual spatial intelligence learn more effectively by looking at pictures/images. In a study conducted by Boakes (2009), spatial/visual was stated to be an important part of geometrical thinking.

### Mathematics literacy abilities of kinesthetic students

Based on the results of the TKLM, the kinesthetic type students indicated a homogeneous ability on the written test at level 1. The in-depth interviews portrayed that the average ability of students' achievement was also classified at level 1.

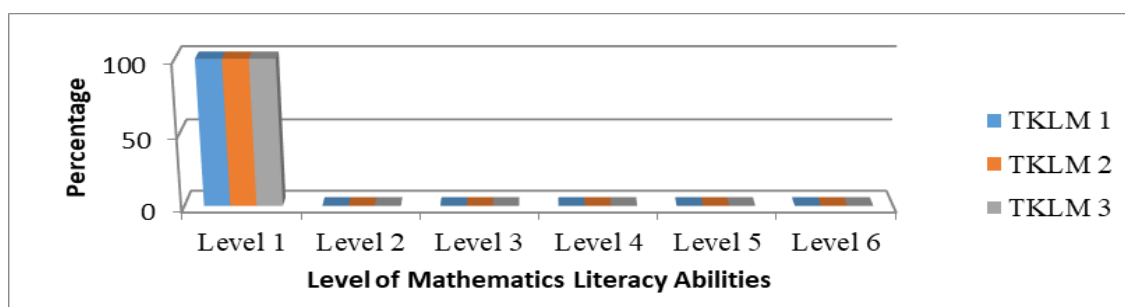


Figure 4. Level of mathematics literacy abilities of kinesthetic students.

### Mathematics literacy abilities of musical students

Based on the results of the TKLM, the musical students had heterogeneous abilities on written tests. The in-depth interviews indicated that the average ability of students' achievement was categorized at level 2.



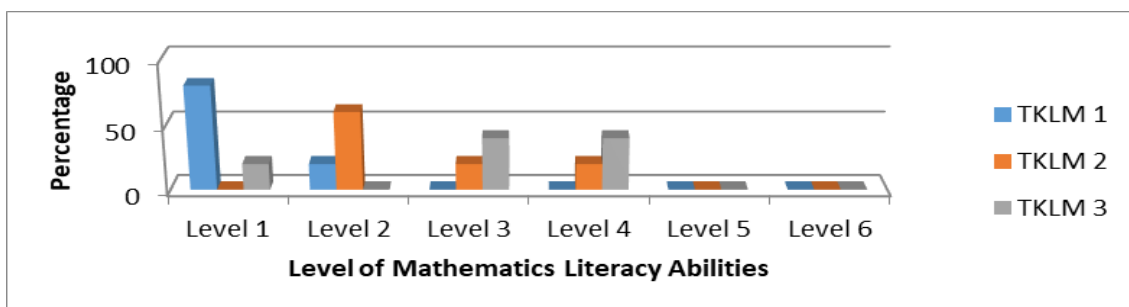


Figure 5. Level of mathematics literacy abilities of musical students.

The notable aspect of the musical students lies in their analysis and representation. They could convey ideas in solving mathematical literacy problems, which corresponds with the study by Damar (2012), which stated that there was a positive and significant relationship between musical and mathematical abilities.

### Mathematics literacy abilities of intrapersonal students

Based on the results of the TKLM, the intrapersonal students had various abilities on written tests. The in-depth interviews revealed that the average ability of students' achievement was at level 2. The mathematics literacy skills of the intrapersonal students were at level 2.

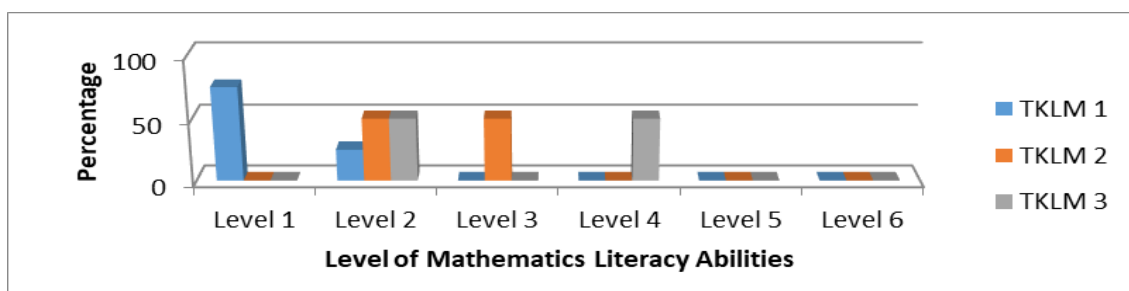


Figure 6. Level of mathematics literacy abilities of intrapersonal students.

The intrapersonal students convey ideas well in solving the problems which resembles the finding of Febriyanti (2018), which stated that students with intrapersonal intelligence communicate well in writing mathematics. During interviews, the students expressed their preferences on literacy problems in the form of simple questions because simple questions made them easier to find out information from the questions.

### Mathematics literacy abilities of interpersonal students

Based on the results of the TKLM, the interpersonal students had a homogeneous ability on written tests. The in-depth interviews demonstrated that the average ability of students' achievement was at level 1, and thus the mathematics literacy abilities of the interpersonal students were low.

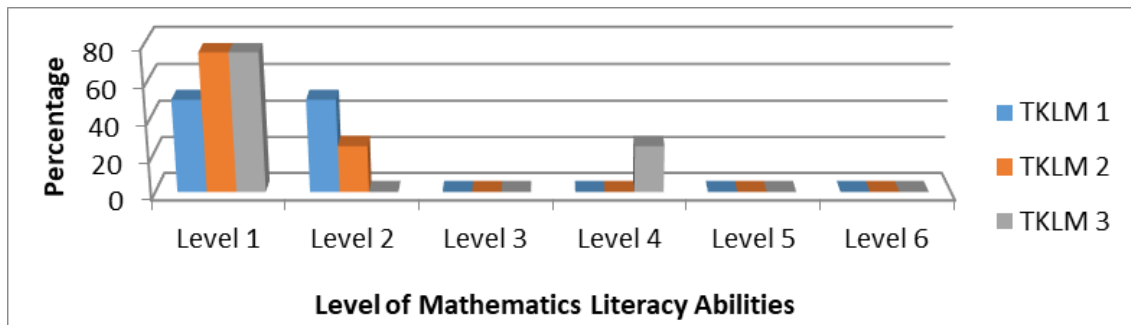


Figure 7. Level of mathematics literacy abilities of interpersonal students.

This research, however, contradicts the results of Hidayati (2014), which stated that students' mathematics learning achievement with high intrapersonal intelligence is better than those having moderate and low intrapersonal intelligence. This study is supported by the results of the in-depth interviews, in which one student could reach level 4.

### Mathematics literacy abilities of naturalist students

Based on the results of the Mathematical Literacy Ability Test (TKLM), the naturalist students had a homogeneous ability on written tests of mathematics literacy questions. From the results of in-depth interview, the average achievement of naturalist students in the mathematics literacy was at level 1.

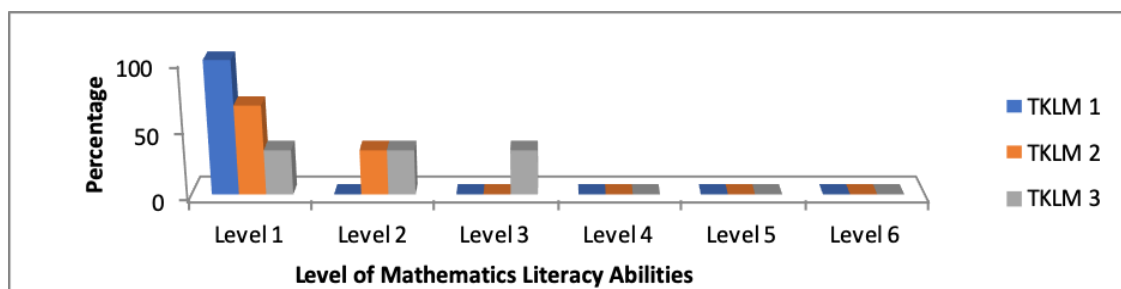


Figure 8. Level of mathematics literacy abilities of naturalist students.

The students could not provide complete arguments or explanations, which is in accordance with Gardner (2011), who explained that the naturalist students have less ability in delivering their ideas for solving the mathematics problems but they are outstanding when asked to look for the data from the surrounding environment.

### Conclusion and Suggestion

This research acknowledges the small sample size but can generate the following conclusion points.

- (1) the quality of mathematics learning in the Cognitive Growth model of mathematical literacy abilities was in the good category, and this result is evident in the three domains of quality learning criteria that include (a) planning and preparation, (b) classroom management and organization (process), and (c) assessment (evaluation).
- (2) the classification of mathematics literacy abilities of the cognitive growth learning model in terms of the multiple intelligences, are verbal/linguistic, logical/ mathematical, and musical-typed students classified at level 4, visual/spatial students categorized at level 3, intrapersonal-typed students classified at level 2, while kinesthetics, interpersonal, and naturalist students are at level 1.

The Cognitive Growth model may be useful in monitoring the students' mathematics literacy abilities. However, further research is needed to expand the observed dimensions, for example in terms of the students' ability to think logically, creatively, and cognitively. These dimensions are estimated to influence the students' mathematics literacy abilities.

### References

- Ali, H. H., & Jameel, H. T. (2016). Causes of poor performance in mathematics from teachers, parents and student's perspective. *American Scientific Research Journal for Engineering, Technology, and Sciences*, 15(1), 122-136.
- Boakes, N. J. (2009). Origami instruction in the middle school mathematics classroom: Its impact on spatial visualization and geometry knowledge of students. *Research in Middle Level Education*, 32(7), 1-12.
- Damar, K. (2012). *Hubungan antara kemampuan musikal dengan kemampuan matematika siswa SMPN 1 minggu sleman* [Unpublished Master Thesis]. Universitas Negeri Yogyakarta.
- Depdiknas. (2003). *Sistem Pendidikan Nasional*. Jakarta: Depdiknas.
- Febriyanti, R. (2018). Students' mathematical communication abilities in mathematical problem solving viewed from intrapersonal and interpersonal intelligences. *MATHEdunesa*, 7(1), 93-100.
- Gardner, H. (2011). *The theory of multiple intelligences: As psychology, as education, as social science* [Address]. honorary degree from José Cela University in Madrid, Spain, and the Prince of Asturias Prize for Social Science.
- Gagne, R.M. (1985). *The condition of learning and theory of instruction* (4th ed.). New York: Holt, Rinehart and Winston.
- Gouws, F.E. (2007). Teaching and learning through multiple intelligences in the outcomes-based education classroom. *African Review Journal*, 4(2), 60-74.
- Hidayati. (2014). Eksperimentasi pembelajaran matematika dengan model pembelajaran kooperatif jigsaw dan teams games tournament (TGT) ditinjau dari kecerdasan intrapersonal siswa. *Jurnal Elektronik Pembelajaran Matematika*, 2(2), 152-162.
- Joyce, B., & Weil, M. (1992). *Models of Teaching* (4th ed.). London: Allyn and Bacon.
- Mac Gregor, R. R. (2007). *The essential practices of high-quality teaching and learning*. Bellevue, WA, US: The Center for Educational Effectiveness, Inc.
- Männamaa, M., Kikas, E., Peets, K., & Palu, A. (2012). Cognitive correlates of math skills in third-grade students. *Educational Psychology*, 32(1), 21-44.
- Ningsih. (2014). Kecerdasan visual spasial siswa SMP dalam mengkonstruksi rumus pythagoras dengan pembelajaran berbasis origami di kelas VIII. *Jurnal Ilmiah Pendidikan Matematika*, 3(1), 203-211.
- OECD. (2009). *Learning mathematics for life: A perspective from PISA*. Paris: OECD Publishing.

- OECD. (2013). *PISA 2012 results in focus what 15-year-olds know and what they can do with what they know*. Paris: OECD Publishing. Retrieved from <http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf>.
- OECD. (2016). *PISA 2015: PISA results in focus*. Paris. PISA-OECD Publishing.
- OECD. (2012). *PISA results: What students know and can do – Student performance in mathematics, reading and science*. Paris: OECD Publishing.
- Rafianti. (2013). *Penerapan model pembelajaran berbasis multiple intelligences untuk meningkatkan kemampuan pemahaman konsep, penalaran matematika, dan self-confidence siswa MTs*. Bandung: Universitas Pendidikan Indonesia.
- Rusmining, Waluya, S. B., & Sugianto. (2014). Analysis of mathematics literacy, learning constructivism and character education. *International Journal of Education and Research*, 2(8), 331-340.