The instrument for measuring logical-mathematical intelligence of low-grade elementary school students

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Abstract. The limited measurement of students' multiple intelligence, especially students' logical-mathematical intelligence, is the main reason for this research. The purpose of this study is to produce instruments to measure the logical-mathematical intelligence of low-grade elementary school students. Research and Development are used in this research. The study population was all students in Purwakarta. The sampling technique was purposive sampling. The sample was 27 students of the second-grade elementary school in Purwakarta. Validity testing produces nine indicators that are represented by five activity items that are observed through an observation sheet having high validity. The reliability test results through the Cronbach’s Alpha calculation produce a stable instrument with a value of 0.81 $> 0.60$ for all items. Thus, logical-mathematical intelligence instruments can be utilized in learning in low-grade elementary schools.

1. Introduction

Mathematics is considered a useful subject for daily life. But most students feel mathematics is a difficult subject, including elementary school students. Mathematical assumptions are difficult due to traditional learning methods and do not develop mathematical prerequisite competencies. The math prerequisite competency that students must possess is adaptive reasoning. Adaptive reasoning refers to the ability to think logically about the relationship between concepts and situations [1]. Besides that, the purpose of learning mathematics for elementary schools including (1) Explain the interrelationships between concepts and situations; (2) Use reasoning on patterns and traits, make generalizations, compile evidence, or explain mathematical ideas and statements; (3) Solve problems through understanding problems, designing mathematical models, solving models and interpreting the solutions obtained; (4) Communicate ideas with symbols, tables, diagrams, or other media to clarify the problem; (5) Having an attitude of appreciating the usefulness of mathematics in life, curiosity, attention, and interest in learning mathematics, being tenacious and confident in problem-solving [2].

The description informs students are required to have mathematical competence in the form of logical thinking in reasoning to connect understanding and solve mathematical problems. This competence is called logical-mathematical intelligence. Supporting this education serves to develop intelligence or multiple intelligences [3]. One of the multiple intelligences is logical-mathematical. If this intelligence
is ignored, it will hamper mathematics learning in the classroom. Logical-mathematical intelligence is the ability to reason or calculate logically, mathematically, see or recognize patterns and analyze abstract patterns, deductive-inductive and rational thinking [4]. Logical-mathematical intelligence is useful to characterize the arithmetic system by the group and to estimate the reasonable object, individual, or organism of a field well, logical-mathematical intelligence makes it easy to understand patterns wherever they are: thus individuals with logical-mathematical abilities strong might be in a favorable position to distinguish metaphors [5]. Students with logical-mathematical intelligence will use numbers effectively and reason well, sensitive to patterns and logical relationships, statements and propositions, functions, and abstractions [6]. Thus, mathematical logical intelligence is interpreted as a competency to understand and analyze numbers well, reason, and connecting between patterns to solve problems.

However, several studies inform students' mathematical logical intelligence is still limited. The study says that the mathematical logical intelligence of elementary school students in Aceh has not yet function optimally in understanding and solving mathematical problems [7]. The low logical intelligence of students is still seen in subjects who seem not to understand the concept of comparison correctly [8]. The limitation of students' mathematical logical intelligence is still important to be developed by first-grade teachers. Because logical-mathematical intelligence is useful in high-class mathematical concepts. Mathematical logical intelligence is developed through several indicators that show the development of such intelligence. Mathematically logical-mathematical intelligence can be found through identifying and classifying objects, doing mathematical calculations, solving problems, thinking logically and critically, and making conclusions [8].

Based on the description the indicators measured in mathematical logical intelligence include feeling objects in the environment and the functions of these objects, familiarity with the concepts of quantity, time, and cause and effect, showing expertise with logic to solve problems, propose, and test hypotheses, create models new in science and mathematics, using various skills in mathematics, enjoying complex operations, using technology in solving mathematical problems, showing an interest in the exact sciences. The nine indicators will be represented by five activities that the teacher will observe. The logical-mathematical intelligence indicator is observed by the observation process using an observation sheet. There is also a study saying logical-mathematical intelligence can be developed by exposing students to various opportunities by being given problems to solve, conducting their experiments, making predictions and testing them, classifying, classifying the information, and finding relationships [9]. The level of students' mathematical logical intelligence becomes a reflection of the teacher’s developing learning, especially in learning mathematics and science that requires good logic skills. Students who have logical-mathematical intelligence will easily solve mathematical story problems because they can understand, interpret, translate the mathematical story problems [10].

The usefulness of mathematical logical intelligence requires compatible instruments to be able to measure well. Good instruments can be achieved through data and can be interpreted better through a process that is reliable, valuable, and objective [11]. The instrument is considered to be able to measure well if the validity and reliability are good. Agreeing with the theory that a good instrument must meet two important requirements, namely valid and reliable. To find out the validity and reliability of the instrument, a trial is held first [12]. If $r_{count} \geq r_{table}$ then the instrument is valid. While the Cronbach Alpha value reflects the reliability of the instrument. If the Cronbach Alpha value $> 0.60$, the instrument is reliable. To determine the reliability of the method by comparing the value of the $r$ table with the value of $r$ alpha [13]. Thus, researchers must consider the appropriateness of the instrument before developing and analyzing research results. If the assumptions are empirically proven, the instruments developed in the study have good predictive validity [14]. A good instrument will produce correct data so that conclusions are by reality [15]. Thus, this research will create a good instrument and can measure the mathematical logical intelligence of elementary school students in low grades.
2. Methods
Research and Development were applied in this study. This method will produce mathematical logical intelligence instruments for analysis of further research in low-grade elementary schools. The population of this research is all elementary school students in Purwakarta Regency. Determination of the sample with the aiming sample. The mathematical logical intelligence test instrument was tested on the second-grade sample of 27 students as a higher class of research to be carried out further, namely first grade and having better maturity. Mathematical logical intelligence instruments will determine the level of mathematical logical intelligence of students in certain learning. Measurement of observations of mathematical logical intelligence is guided by a Likert scale through four criteria, namely, Very Good Developing, Developing as Expected, Starting Developing, and Not Developing. Scores on each criterion based on established rules are 4 for developing very well, 3 for developing according to expectations, 2 for starting to develop, and 1 for not developing yet [16]. The observation sheet instrument created in the study was tested to find out the logical intelligence of first-grade elementary school mathematics. The first step of the lattice analysis is related to indicators, and observed activity items. Furthermore, the grid is consulted with a team of experts on the alignment of indicators with activities. This step is carried out with recommendations from lecturers of Early Childhood Teacher Education, Guidance and Counselling, and Elementary School Teacher Education, as well as tests of student understanding of the statements observed by teachers. The decision of the expert team determined that the five items representing nine indicators of logical-mathematical intelligence could be tested, through a slight change of words. Before the validity and reliability of the test results were analyzed the observation sheet was changed from the ordinal scale to the interval. Validity refers to whether an instrument is good at measuring. In other words, a valid measure measures what is claimed to be measured, while reliability refers to the consistency or stability of the measurement instrument. Thus, instruments measure the same way each time they are used [17]. Analysis of validity and reliability using SPSS 25 application assistance using Pearson product-moment correlation test for validity and Cronbach's Alpha for reliability. To interpret the criteria of validity and reliability based on the correlation coefficient (r) presented in Table 1 below [18]:

| Correlation Coefficient | Interpretation of Reliability | Interpretation of Validity |
|-------------------------|------------------------------|---------------------------|
| 0.80 to 1.00            | Very stable                  | High                      |
| 0.60 to 0.79            | Stable                       | Medium                    |
| 0.30 to 0.59            | Not stable enough            | Low                       |

3. Results and discussion

3.1. Indicators and activities of mathematical logical intelligence
Mathematical logical intelligence is observed through observation sheets based on indicators and activities that have been prepared. Development of logical intelligence instruments using reliability validity testing. The higher the validity of an instrument, the better the level of meaningfulness and usefulness [19]. Reliability describes the size that shows the results of the measurement instruments they provide stable and consistent results in repeated testing [20]. Before testing the validity and reliability of the instrument, the researcher develops indicators and examples of activities that are observed based on several literature studies. The indicators and activities on the observation sheet to measure mathematical logical intelligence are listed in table 2:
Table 2. Indicators and logical-mathematical activities of students.

| Item | Indicators                                                                 | Examples of observed activities                                                                 |
|------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| 1    | Feeling objects in the environment and the functions of these objects.   | Explain the usefulness of objects in the vicinity                                                |
| 2    | Feel familiar with the concepts of quantity, time and cause, and effect  | Mention and tell the types of activities carried out in the morning                             |
| 3    | Demonstrate expertise with logic to solve problems                       | Explain how to deal with avoiding flood disasters                                                |
| 4    | Propose and test hypotheses                                              |                                                                                                  |
| 5    | Creating new models in science and mathematics                           |                                                                                                  |
| 6    | Able to use various skills in mathematics                                |                                                                                                  |
| 7    | Enjoy complex operations                                                 |                                                                                                  |
| 8    | Using technology in solving mathematical problems                        |                                                                                                  |
| 9    | Showing interest in the exact sciences                                    |                                                                                                  |

The instrument that will be used should have good quality [21]. To produce high-quality research, a good instrument is required [22]. The preparation of mathematical logical intelligence instruments was developed through the introduction, development, and testing of instruments. Agreeing with that, the instrument development was carried out in several stages. The first stage defines the development of instruments. The second stage, planning the development of instruments and determining indicators. The third stage develops instruments based on selected indicators [23]. The preliminary stage by formulating appropriate data collection techniques to measure the mathematical logical intelligence of low-grade students, in this case, the observation sheet is used to see mathematical logical intelligence. Development phase by determining and analyzing indicators based on literature review and compiling observations based on indicators. The testing phase of the instrument by asking for advice from a team of experts in related fields and revising based on the advice given, then the instrument testing the validity and reliability to determine the level of truth and reliability of the instrument is measuring.

3.2. Instrument validity test analysis

After the instrument has been improved upon the request of the expert team, the instrument is tested for validity and reliability in second-grade elementary school students to understand the quality of the instrument. The following validity test results are presented in Table 3:

Table 3. Analysis of logical-mathematical intelligence validity test.

| Item | Correlation Value ($r_{count}$) | $r_{table}$ ($\alpha=5\%$, $k=n-2=25$) | Direction of Correlation | $p$-value | Criteria | Conclusion |
|------|---------------------------------|----------------------------------------|--------------------------|-----------|----------|------------|
| 1    | 0.839                           | 0.323                                  | positive, $r_{count} > r_{table}$ | 0.000     | Very High| Valid      |
| 2    | 0.772                           |                                       | positive, $r_{count} > r_{table}$ | 0.000     | High     | Valid      |
| 3, 4, 5 | 0.797                        | 0.323                                  | positive, $r_{count} > r_{table}$ | 0.000     | High     | Valid      |
| 6, 7 | 0.767                           |                                       | positive, $r_{count} > r_{table}$ | 0.000     | High     | Valid      |
| 8, 9 | 0.601                           |                                        | positive, $r_{count} > r_{table}$ | 0.001     | High     | Valid      |

Table 3 explains the five activity items representing the nine indicator items tested are valid with high and very high criteria. Then all items are suitable to be used for further research on the measurement of mathematical logical intelligence because the value of $r_{count} > r_{table}$ and the $p$-value is lower than 0.05 = $\alpha$ on all items. Instruments with high validity can be said to meet good criteria as an evaluation tool [24]. Thus, instruments with high validity can measure variables that are measured properly and show actual results. A similar statement informs an instrument with good validity is one that measures what it is supposed to measure (e.g., a measure of coaching skills should provide an accurate indication of an individual's ability to help others enhance their performance [25].
3.3. Instrument reliability test analysis
Testing the validity of the instrument showed that five activity items on nine indicators were considered valid. The instrument reliability testing is then performed. Reliability testing using Cronbach’s Alpha with the help of SPSS version 25. Measuring the reliability of the instrument of logical-mathematical intelligence observation sheets through Cronbach’s Alpha because it can measure the reliability of instruments that have many choices of answers. Agree with these reasons, the selection of Cronbach’s alpha as a measure of instrument reliability for measuring instruments is because Cronbach’s Alpha can test a questionnaire-type instrument that has more than one answer [21]. The results of the reliability testing of the students' logical-mathematical intelligence observation sheet are listed in the following table 4:

Table 4. Results of logical-mathematical intelligence instrument reliability tests with Cronbach’s Alpha.

| Cronbach’s Alpha | N of Items |
|------------------|------------|
| 0.811            | 5          |

The instrument reliability test results show a Cronbach Alpha value of 0.811 so that the five items have very stable or high-reliability. The use of instruments with high-reliability values is important, not only getting stable estimates but is a time and energy-saving strategy [26]. It is essential to use instruments with good reliability to ensure that the research findings as well as instructional and policy decisions on instruments that measure what purports to measure [27]. Thus, instruments with stable reliability can be used many times in research to measure students' logical-mathematical intelligence. Well-established instruments with good reliability were used to measure the study's outcomes [28].

4. Conclusion
The logical-mathematical intelligence instruments of low-grade students that have been developed have validity and reliability criteria of stability and high so that the logical-mathematical intelligence instruments through the observation sheet created can measure well and consistently.

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