THE VALIDITY AND RELIABILITY OF INSTRUMENTS FOR MEASURING ELEMENTARY SCHOOL STUDENTS' EARLY MATHEMATICAL ABILITY

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ABSTRACT

Teachers need to understand students' early mathematical abilities before continuing learning on the next topic to retain the knowledge. This study aims to produce appropriate and reliable instruments for quality research related to early mathematical abilities. This research implemented R&D. The subjects were 113 sixth-grade students of the elementary school in Karawang. The instrument used was a test to measure early mathematical ability. Validity and reliability tests indicated that the five initial mathematical ability test items were considered valid, with $r_{count} > r_{table}$ and p-value <0.05. The Cronbach's Alpha value was 0.875 (above 0.8 or high reliability). Thus, the five items of the early mathematical ability instrument on the volume of cubes and rectangular prisms can be used for further research to measure the same variables accurately. The results are not significantly different for the same subject even though the time and place are different.

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INTRODUCTION

Mathematics is taught to students to help them organize logical reasoning, display personalities, and use mathematics and mathematical reasoning in real-life situations (Soedjadi, 2004). Mathematics in schools has its own goals, often meaningless manipulation of numbers, while mathematics serves as a means to achieve other goals, gives meaning to calculations related to everyday life, as a useful context for concentration, and can support persistence (Galla, Esposito, & Fiore, 2020; Rampal, 2003). This goal will be achieved if students' understanding of the previous topic is good. Prior understanding is very important for students and is a target for the learning process (Shabrina & Sumiati, 2020).

However, mathematics teachers in elementary schools sometimes tend to convey material directly without paying attention to students' understanding of the previous material. This is evident in studies that found several obstacles faced by teachers. For example, when the teacher teaches thematic material in the fourth grade, the acquisition of students' knowledge competencies is not optimal; this can be proven by the competence of previous knowledge below the Minimum Criteria of Mastery Learning (Luh, Santiasih, Ganing, & Sujana, 2016). Previous understanding will affect how a person is involved in the new understanding (Ardiyanti, 2016). Previous understanding can build and develop mathematical concepts learned from understanding (Fatqurhohman, 2016). Prior understanding can be used to be aware of situations and determine strategies through thinking (Salayan & Ariswoyo, 2020).

In learning mathematics, students need a solid foundation to understand the previous material to reach the next level. For example, to understand the topic of the volume of cubes and rectangular prisms, students must understand previous topics or prerequisites, such as arithmetic operations, area, and perimeter of shapes, measurement of units of length and volume, story problems, and other prerequisite topics. The previous understanding is referred to as Early Mathematical Ability. Early Mathematics Ability is the student's ability to understand the prerequisite material (Yuliyanto & Turmudi, 2020). Students who know previous materials could follow and do the next learning (Jamaan, Musnir, & Syahrial, 2020; MacDonald & Carmichael, 2018). Early mathematical abilities can affect stable characteristics, affecting mathematics achievement over time (Watts et al., 2017). Students' early mathematical abilities also affect students' mathematical dispositions (Noviana, Hadi, & Handayani, 2020). Thus, early mathematical ability is a prerequisite ability to support mathematics learning in subsequent topics.

Previous research related to Early Mathematical Ability stated that the Realistic Mathematics Education Approach not only improves mathematical literacy in eighth-grade junior high school students with high early mathematical abilities, but also students with low early mathematical abilities on statistics topics (Sutisna, Budi, & Noornia, 2018). Regarding the interaction of early mathematical abilities with learning, it was found that there was no interaction between learning and Early Mathematical Ability in improving the reasoning abilities of eighth-grade junior high school students (Ayal, Kusuma, Subandar, & Dahlan, 2016). Through qualitative research, the development of students' early math abilities could be handled well by not only focusing on early math concepts at home but also by focusing on developing learning behaviors, such as engagement, resilience, curiosity, and challenge seeking (Kritzer, 2012). The parental reports about the amount of children's activity at home predicted the children's performance on standardized early math ability tests (Blevins-Knabe & Musun-Miller, 1996). The problem-based learning approach had a significant effect on the critical thinking skills of high school students in terms of school level and early mathematics abilities (Widyatiningtyas, Kusumah, Sumarmo, & Sabandar, 2015).

Previous studies above have revealed that early mathematical abilities have been examined quantitatively and qualitatively for junior high school and high school students. It also has been examined based on the parents and related statistics. However, instruments for measuring students' early mathematical abilities, especially in elementary schools, are limited. Therefore, this research revealed an instrument to measure the early mathematical ability of fifth-grade elementary school students on the topic of cubes and rectangular prism using the R&D research method.

A tool is needed to measure students' early mathematical abilities appropriately to conduct research or learning mathematics by reviewing students' early mathematical abilities before proceeding to the next topic. Thus, it can be used to determine the students' previous understanding of the topic being taught. That is because to produce high-quality research; reliable instruments are needed (Putri, Wahyudy, Yuliyanto, & Nuraeni, 2020). An assessment instrument is a tool used to make an assessment or evaluation, an instrument can be a test or non-test, and observation can be carried out in two ways, namely systematic and non-systematic observation. (Rafianti, Anriani, & Iskandar, 2018). The Good instruments meet certain rules, provide accurate data according to their function, and only measure samples of certain behaviors. The characteristics of a good evaluation instrument are valid, reliable, relevant, representative, practical,

discriminatory, specific, and proportional (Siswantari & Maretha, 2020). Furthermore, empirical validation is carried out through validity and reliability tests to ensure that they can measure the measured variables and produce similar results even though they are used repeatedly (Putri et al., 2020). The validation of the research instrument aims to measure whether the instrument made is per the measurement assessment by the validator (Setyansah, 2020).

Thus, a good instrument must have validity, namely the accuracy of an instrument in measuring the variable to be measured, and reliability, namely the instrument's stability in measuring the measured variable repeatedly, at different times and places with the same subject. Validity can identify and be useful in determining the management of education compared to tests based on theoretical frameworks and other perspectives (Scheuer, Herrmann, & Bund, 2019). A valid instrument can estimate the effect of an unbiased treatment. However, at the same time, it is not possible to ensure that all the assumptions necessary for the validity of the instrument have been met. (Rassen, Brookhart, Glynn, Mittleman, & Schneeweiss, 2009). Thus, the validity measurement must be executed through logical validity with expert considerations and empirical validity by testing on a predetermined sample that is not part of the sample to be studied, at least one level above it. Validity can be quantified using Pearson's product-moment correlation coefficient (r) (McNamara, Hudson, & Taylor, 2010).

Meanwhile, reliability is measured by determining the Cronbach's Alpha value because this study will use an essay-formed test instrument. Cronbach's Alpha is suitable for instruments in the form of essays or questionnaires (Yusup, 2018). Reliability can be understood as the consistency of test measurements when the measuring procedure is repeated (Baumgartner, Oh, Chung, & Hales, 2002; Scheuer et al., 2019). Reliable instruments will achieve the same conclusions when applied to the same subjects at different times (Fan, 2018). Thus, this research will produce an appropriate and reliable instrument to measure the early mathematical abilities of fifth-grade elementary school students on the topic of volume cubes and rectangular prisms through validity and reliability trial.

METHOD

This research employed the R&D method. R&D is a systematic process to develop, improve, and assess education programs and materials (Gall, Gall, & Borg, 2010; Jackson, 2009). The design used was ADDIE (Analysis, Design, Development, Implementation, and

Evaluation). The purpose of this study was to produce an accurate and reliable instrument for measuring the early mathematical abilities of fifth-grade elementary school students on the volume of cubes and rectangular prisms. This study was conducted because some teachers still pay less attention to the extent of students' early mathematical abilities and tend to directly continue the topics that must be taught to their students. At the same time, the early mathematical ability of students is necessary to be understood by teachers before continuing with more complex materials requiring fundamental concepts. Studies explained that early mathematical abilities can be in the information of concepts, principles, procedures, and facts that a person already has (Nismawati, Nindiasari, & Mutaqin, 2019). Sixth-grade elementary school students in West Java were the population in this research. The samples were 113 elementary school students in Karawang Regency, West Java, selected by purposive sampling. The results of the development of this test instrument used to measure the early mathematical abilities of fifth-grade elementary school students. The topic developed was related to the volume of cubes and rectangular prisms, so students must understand prerequisite topics, including numerical count operations, calculating square roots, determining the area of a two-dimensional shape, measuring long units, and finally, problem-solving.

The scoring guidelines in this study were modified from Facione (1994), as presented in Table.

Table 1. Guidelines for Scoring Students' Early Mathematics Ability

Score	Criteria
4	The solution is explained in full, almost all instructions are followed, the presentation is logical according to mathematical concepts, and there are no drawing/calculation errors.
3	The solution is explained correctly, there are few errors in calculation/drawing, and the presentation is logical.
2	Solutions are explained incorrectly, answers appear to be trial and error, and the presentation is less logical
1	The interpretation is incorrect, the answers seem trial and error, and the presentation is not logical
0	No response

The development of instruments was carried out based on logical validity and empirical validity. In logical validity, by considering three math experts in elementary schools based on the accuracy according to the content studied, the accuracy of wording, and psychological constructs, a readability test was carried out on students. Furthermore, empirical validity is taken by testing it on students who are not research samples, specifically at least one level above it, i.e., students in six-grades elementary schools; this is because these students have been deemed to have mastered the topic be tested. Data analysis using SPSS 25. The validity decision is identified based on the value of the correlation coefficient (r_{xy}) and reliability based on the value of Cronbach's Alpha. If the sign on the validity test < 0.05 and t_{count} is positive and $> r_{table}$, the instrument is considered

valid (Mahendra, 2015). Meanwhile, if the value of Cronbach's Alpha> 0.70 then the instrument is accepted, while Cronbach's Alpha> 0.8, the reliability is very good (Wells, Russell, Haraoi, Bissonnette, & Ware, 2011). The interpretation of validity and reliability is based on the criteria developed by Guilford (1956) in Table 2.

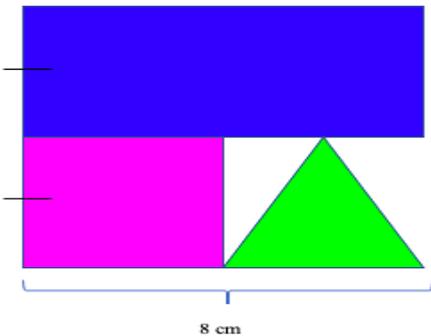Table 2. Interpretation of Test Validity and Reliability of Instruments

r_{11}	Interpretation of Reliability	r_{xy}	Interpretation of Validity
0.80 to 1.00	Very High	0.90 to 1.00	Very high
0,60 to 0,80	High	0,70 to 0,90	High
0,40 to 0,60	Intermediate	0,40 to 0,70	Moderate
0,20 to 0,40	Low	0,20 to 0,40	Low
< 0.20	Very Low	0.00 to 0.20	Very Low
		< 0,00	Not Valid

RESULTS AND DISCUSSION

Early Mathematical Ability

It has been explained that the early mathematical ability is the prerequisite ability that students have for understanding the next topic. In this research, early mathematical abilities were developed to understand the prerequisite abilities of students to study the topic of volume cubes and rectangular prisms. The blueprint for the initial mathematical ability instrument produced is shown in Table 3.

Table 3. Blueprint early mathematical ability instrument

Items	Indicator	Questions	Level of Difficulty
1	Doing arithmetic calculations in numerical count operations	$8 - 6 \times 8 : 10 + 2 = ...$	Easy
2	Calculating the square root	$\sqrt{225} \times (\sqrt[3]{1000} - \sqrt[3]{125}) = ...$	Moderate
3	Determining the area of a two-dimensional	Pay attention to the shape below. Calculate the area of the three shapes! 8 cm	Difficult
4	Calculating the measurement of length units	$5,000 \text{ cm} + 15 \text{ km} \times 5 \text{ dm} - 8 \text{ dam} = ... \text{ m}$	Difficult
5	Solve problem-solving problems	Mr. Adi wants to make a terrace on the left and right of his villa with a length of 7 meters and a width of 5 meters for the left side terrace and the right-side terrace, the size of each side is 4 meters. Then how wide are the two terraces?	Difficult

Students are required to understand several topics at the previous meeting developed in this research to understand the volume of cubes and rectangular prisms, such as in item 1 about doing arithmetic calculations in numerical count operations with problems 8 - 6 x 8: 10 + 2 = ... This problem will encourage students' abilities when performing volume calculation operations for cubes and rectangular prisms. Furthermore, in item 2 about calculating the square root with the problem $\sqrt{225}$ x ($\sqrt[3]{1000}$ - $\sqrt[3]{125}$) = ... This problem will help students when learning the operations to calculate squares and cubic on the volume of cubes and rectangular prisms. Furthermore, in item 3 about determining the area of a two-dimensional like the problem in Figure 1.
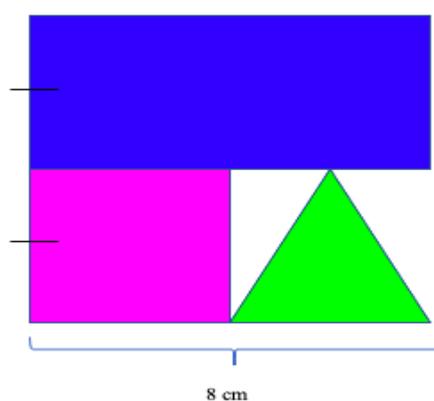

Figure 1. Problem Finding the Combined Area of the Construct.

Pay attention to the shape above. Calculate the area of the three shapes! In this problem, students are trained to discover the area of combined shapes; the questions will be useful for understanding the calculation of the volume of cubes and rectangular prisms combined. Furthermore, item 4 is about calculating the measurement of length units such as 15,000 cm + 15 km x 5 dm - 8 dam = ... m. This problem will help students remember how to modify the unit of length, which will help students how to modify the volume unit. Furthermore, item 5 is about solving problem-solving problems such as the following questions: Mr. Adi wants to make a terrace on the left and right of his villa with a length of 7 meters and a width of 5 meters for the left side terrace and the right-side terrace, the size of each side is 4 meters. Then how wide are the two terraces? This question will train students on story problems in determining the volume of cubes and rectangular prisms, for example, in questions of determining the volume of bath water and dipping water. After the five instruments were developed, then the instrument validation was conducted. The validation of the research instrument aims to measure whether the instrument made is by the measurement assessment by the validator (Haryanti & Saputro, 2016; Setyansah, 2020).

Validity Test Analysis

The five items that have been constructed through logical validity are then tested for empirical validity. Following are the results of the validity trial presented in Table 4.

Table 4. Analysis of Early Mathematical Ability Validity Test

Item	Correlation Value (r_{count})	r_{table} (α=5%, k= n-2=111)	Direction of Correlation	p-value	Criteria	Conclusion
1	0.730		positive, $r_{count} > r_{table}$	0.000	High	Valid
2	0.877		positive, $r_{count} > r_{table}$	0.000	Very High	Valid
3	0.871	0.178	positive, $r_{count} > r_{table}$	0.000	Very High	Valid
4	0.809		positive, $r_{count} > r_{table}$	0.000	Very High	Valid
5	0.840		positive, $r_{count} > r_{table}$	0.000	Very High	Valid

Based on the results of the item validity test in table 4, all items have a significant value with p-value < 0.05 and all $r_{count} > 0.178 = r_{table}$ and are positive so that all items are valid with the criteria item 1 is high, and others are very high in terms of the correlation coefficient according to (Guilford, 1956). The study said that the instrument is classified as valid if it has a positive and significant coefficient < 0.05 (Muhsin, Slamet, & Wahyudin, 2017; Yusof, Bahari, & Adnan, 2014). It is also known that the lowest correlation value is 0.730. Meanwhile, the correlation coefficient <0.3 is low, 0.3-0.5 is moderate, while> 0.5 is high (Tsang, Royse, & Terkawi, 2017). Instruments with a minimum correlation of 0.5 are considered capable of uncovering important and relevant issues to be observed (Masood, Masood, Saub, & Newton, 2014). Thus, all items are considered to measure the early mathematical ability of the volume of cubes and rectangular with high accuracy.

Reliability Test Analysis

The analysis of the validity test indicates that the five items of the instrument are classified as valid and can measure correctly. To discover the instrument's stability in measuring the same subject, but at different times and places, a reliability test was carried out by determining the Cronbach's Alpha value. The summary of the instrument reliability test is listed in Table 5.

Table 5. Results of Early Mathematical Ability Instrument Reliability Tests

Cronbach's Alpha	N of Items
0.875	5

Cronbach's Alpha value shows the instrument has very good stability. Research says that an instrument with a Cronbach's Alpha value> 0.70 can be concluded that all statements are reliable and can be used for further analysis (Astutik & Priantono, 2020; Bolarinwa, 2015; Lima-Rodríguez, Lima-Serrano, & Domínguez-Sánchez, 2015; Tsang et al., 2017). Because the instrument has excellent consistency, the instrument can be used to measure variables that are measured repeatedly with similar subjects even though the place

and time are different.

Face Validity

Researchers in this study also investigated the advanced validity of the early mathematical ability instruments based on two experts in the field of mathematics education in elementary schools. The quality of the instrument is assessed based on three aspects such as the suitability of the instrument with the indicators, the suitability of the instrument with the material, and the readability of the instrument. Measurement of instrument quality using a scale between 1-5. The following is the results of the instrument quality assessment based on face validity in Table 6:

Table 6. Face Validity Results of Early Mathematics Ability Based on Expert Assessment

No	Assessment Aspect	Average	Criteria
1	Suitability of the instrument with the indicators	3.5	Worth using/ testing with revision
2	The suitability of the instrument with the material	4.7	Worth using/ testing with revision
3	Instrument readability	2.8	Worth using/ testing with revision
	Total Average	3.67	Worth using/ testing with revision

Based on Table 6, the five items of the instrument, according to the experts, are considered suitable to be used to measure early mathematical abilities by requiring some improvements. The research revealed that the eligibility criteria for a product were observed based on a range of 1-5, namely 1.00-2.33 the product was considered unfit for use/tested, 2.34-3.67 the product was considered Eligible to be used/tested with revisions, and 3.68-5,00 products are deemed Eligible for use/ tested without revision (Arikunto, 2012). Reviewing the results of the instrument quality assessment according to the experts shows that the five items are considered good enough and deserve to be tested on the respondents to measure how well the students' early mathematical abilities are with a slight improvement before being tested. An in-depth assessment of an instrument must be carried out to find out how appropriate the measuring instrument is in measuring the aspects measured when used in the field. Supporting this, before implementation, the product developed was assessed for quality first by asking for an assessment from a team of experts (Wijayanti, Saputro, & Nurhayati, 2015).

CONCLUSION

The development of early mathematical ability instruments related to the volume of cubes and rectangular prisms have been consulted with experts and tested on 113 fifth-grade elementary school students in Karawang. The validity and reliability test showed that the five items have good accuracy and reliability in measuring early mathematical abilities on the volume of cubes and rectangular prisms and can measure the same variables and

subjects at different times and places in subsequent research. Early mathematical abilities are considered the foundation for students in studying the topics to be studied, so teachers are suggested to understand students' early mathematical abilities before continuing learning. To understand students' early mathematical abilities, teachers can use an instrument of a test with appropriate aspects and indicators as developed in this study.

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