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Research Article

Development of Mathematical Connection Ability Instruments for Elementary School Students

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Abstract.
This research is motivated by the importance of mathematical connection skills. Based on the results of previous studies, it is known that the mathematical connection ability of elementary school students is still low. This study aims to develop a mathematical connection ability instrument suitable for elementary school students. This study uses the research and development method. The samples are 27 sixth-grade students at an elementary school in Purwakarta who were selected through purposive sampling. The ability instrument that has been made is in the form of an essay that consists of five open-ended questions about geometry. The indicators developed in preparing the questions were related to the ability of mathematical connections. The questions were constructed according to expert suggestions followed by a trial to see its validity, reliability, difficulty index, and discriminating power. Results show that the validity and reliability of the test instrument developed in this study are 0.73 and 0.84, implying that the test instrument has high validity and reliability. Questions numbers 1,3, and 5 have a high level of difficulty, while numbers 2 and 4 have a very high level of difficulty. The discriminating power for question number 1 is 47.62% (good), number 2 is 28.57% (fair), number 3 is 38.10% (good), number 4 is 28.57% (fair), and number 5 is 57.14% (very good).Thus, the five test items can measure mathematical connections in learning mathematics on geometry topics for fifth-grade elementary school students and are appropriate for further research instruments on similar subjects and variables.

Keywords: Mathematical Connection, Elementary School, Students

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1. INTRODUCTION

Mathematical connection ability is one of the abilities that elementary school students must have. As explained by the National Council of Teachers of Mathematical (NCTM) Institute, the mathematical connection is one of the essential abilities that students must possess [1, 2]. Mathematical connection is part of a knowledge network interconnected with other knowledge consisting of critical concepts for understanding and developing relationships between mathematical ideas, concepts, and procedures [2–5]. The ability of students to make mathematical connections is an important point that must be

achieved in the process of learning mathematics. By knowing the relationship between mathematical concepts, students can understand mathematics easily and develop abilities in learning mathematics [3]. Students need the ability of mathematical connection to learn various mathematical concepts that are interrelated with each other [3, 6–9].

However, the reality in the field shows that elementary school students do not yet have the expected mathematical connection abilities. This fact is in line with the results of previous studies that state that elementary school students' mathematical connection ability is still low [1, 7, 9, 10]. The low mathematical connection ability of elementary school students is caused because students are not accustomed to solving problems that refer to indicators of mathematical connection ability. Efforts can be made to familiarize students with practicing questions that refer to indicators of mathematical connection ability on HOTS (Higher Order Thinking Skill) level [11, 12].

Previous research has developed a test instrument for mathematical connections for junior high school level [13] and elementary school level, specifically in 3rd grade [14]. However, the mathematical connection instrument for the 5th-grade elementary school level with geometry material for cubes and blocks has never been developed before. This geometry material about cubes and blocks was chosen to be developed because it is part of the essential material for mathematics that is taught on an ongoing basis in elementary school, junior high school, and high school levels [15].

Based on these problems, it is necessary to develop mathematical connection ability instruments for elementary school students. This study aims to develop the valid and reliable instrument to measure the mathematical connection ability of fifth-grade elementary school students, especially in geometry-solid figures topics. It is hoped that the mathematical connection ability instrument resulting from this research can later be used by researchers, teachers, or other educators to measure the mathematical connection abilities of fifth-grade elementary school students.

2. RESEARCH method

This study focuses on developing an instrument for mathematical connection abilities in geometry-solid figures for fifth-grade elementary school students. The method used in this research is Research and Development (R&D) [16, 17]. This research method was chosen based on the research objective to produce an instrument that can be used sustainably. Research and development methods can be used to produce a product and test its effectiveness of the product [18, 19].

The stages of development in this study include: 1) Construct instruments according to indicators of mathematical connection ability; 2) Perform expert judgments to develop and revise instruments before giving it to the samples; 3) Conduct tests on students and score the result; 4) Process student score data using Anates software version 4.0.9 to calculate determine the instrument test items' validity, reliability, level of difficulty, and discriminating power; and 5) Conclude the instrument's feasibility to measure students' mathematical connection abilities [18].

The sample taken in this study was 27 sixth-grade elementary school students in Purwakarta. Sample sizes greater than 20 are considered normally distributed and can be used to approximate the binomial distribution [20]. A sample of 15-30 respondents per group can be used for simple experiments with tight control [21]. Research success can be achieved by using a sample size of 10 to 20 [22]. Based on the opinions of the experts above, the sample size used is sufficient to validate the test instrument. The sampling technique used the purposive sampling technique. In purposive sampling, sampling is based on specific considerations or reasons [23, 24]. The reasons for involving these samples are: 1) the developed test instrument for fifth-grade elementary school, but the sample used is sixth-grade elementary school students who had learned geometry; and 2) it is easy to manage permission because the researcher works in the school where this study takes place. The analysis of the validity and reliability calculations refer to the correlation coefficient criteria from Guilford [11, 12]. Meanwhile, the discrimination power and difficulty level of each test items are interpreted based on [25].

3. result and discussion

The result of this research is the test instrument for the mathematical connection ability of elementary school students. The indicators of mathematical connection ability developed in this study consist of: (1) Connections among mathematical topics, which are various mathematical materials or topics that have connections with each other; (2) connections with disciplines outside of mathematics, which is mathematics that is connected with other subjects that students have studied or will study; (3) connection with the real world or everyday life is a sign that mathematics can be associated with everyday problem-solving [25–27]. Thus, in this study, students are expected to: connect geometry and algebra (the connection between mathematics topics), connect geometry with arts (the connection between mathematics and other disciplines), and connect geometry with everyday life. Before the instrument is tested on samples to

see the validity, reliability, discriminatory power, and difficulty level of the questions, it is necessary to do expert judgment for validation [28]. The expert who gives expert judgment on the connection ability instrument in this study is a professor in mathematics education. The results of expert judgment shows that the instrument is feasible to be used in measuring the mathematical connection ability of fifth-grade elementary school students. Judgement expert results can be seen on Table 1.

TABLE 1: The results of expert judgement.

Aspects	Content Validity	Presentation	Language	Graphic	Total
Item Criteria	9	3	4	2	18
Highest score	4	4	4	4	4
Lowest Score	1	1	1	1	1
Ideal Highest Score	36	12	16	8	72
Ideal Lowest Score	9	3	4	2	18
Mean Score	29.35	9.62	12.62	6.04	57.62
Standard Deviation Score	4.5	1.5	2	1	9
Ideal Mean Score	22.5	7.5	10	5	45
Ideal Percentage	81.52	80.13	78.85	75.48	80.02
Category	Very Good	Very Good	Very Good	Very Good	Very Good

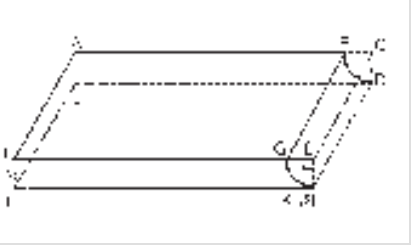
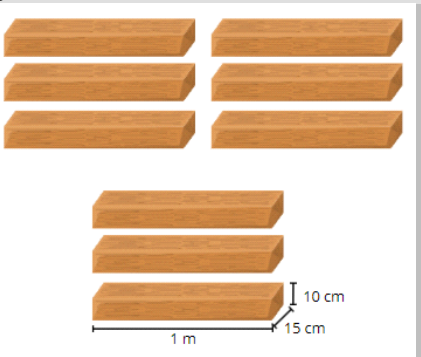
Based on the table above, the mathematical connection ability test instrument that has been made meets the minimum quality standard, which is categorized as very good.

The blueprint of mathematical connection ability test instruments in geometry for fifth-grade elementary school students after revisions based on suggestions from judgment experts can be seen in Table 2.

Five questions that have been revised based on suggestions from experts are then tested on 27 sixth-grade elementary school students to see each question's validity, reliability, discriminating power, and difficulty level. In detail, the results of data processing from testing the mathematical connection ability instrument can be seen in Table 3.

Based on Table 1, it is known that the overall correlation is 0.73, and the test reliability is 0.84. These results indicate that the mathematical connection ability instrument has high validity and reliability [11, 29]. The validity of each item shows that item number 1 has sufficient validity, item number 4 has high validity, while items number 2, 3, and 5 have very high validity. The correlation for item number 1 is significant, and item numbers 2, 3, 4, and 5 are stated to be very significant [10, 24, 25, 29]. The discriminating power for items number 1 and 3 are in a good category, items numbered 2 and 4 are in the sufficient category and item number 5 is in the very good category. These findings

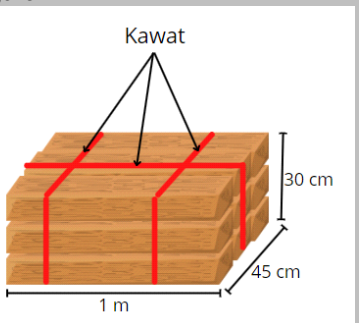
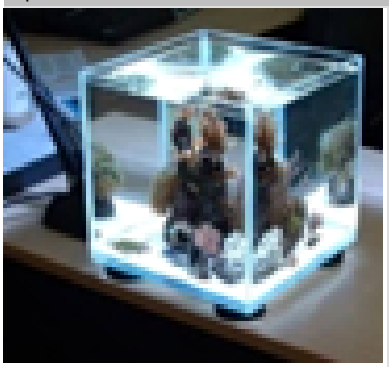
TABLE 2: The blueprint of mathematical connection ability test instruments.

No	Indicator	Item Test
1	Students can connect two mathematical topics (geometry and algebra)	Look at constructed iron plate below!  The sides of HFDJ and ABGI are rectangles. EGF is the 1/4 circle centered on E, and BCD is the shape of a 1/4 circle centered on C. It is known that KF = 1.5 cm, HK = 8 cm, HI = 1.5 cm, and AI = 5 cm. Based on the picture above, how wide is HFGI? Please show me your way to get those results!
		 The blocks will be tied with red wire, as shown above. To tie the blocks properly, Rudi required the wire with an excess of 3 cm in length to be wound. Based on this information, what length of wire is needed to tie the wooden blocks together? Write down your calculations!
2	Students can connect mathematics with another discipline (Connection between geometry on solid figure topics with arts)	There is land that is 50 x 30 m in size. A house will be built on that land. According to that information: Sketch the house plan consisting of a bedroom, kitchen, living room, and bathroom, then categorize the shape of each room on the sketch of the house plan that you made with the rectangular shape marked in blue and a square marked in red! Calculate the total area of the house that you make!

imply that the test items in this study can distinguish students' mathematical connection ability well. The difficulty level for items number 1, 3, and 5 is in the difficult category, while items number 2 and 4 are in the very difficult category. The category used to classify the level of discriminating power, and the difficulty index of the question uses the category from [18, 25].

According to the results explained earlier, it is found that the test items have high validity and reliability and have a significant and very significant correlation. These

TABLE 2: The blueprint of mathematical connection ability test instruments.

No	Indicator	Item Test
3	Students can connect mathematics with the real world or everyday life	Look at the two aquarium figures below. Figure 1  Figure 2  Rudi has two aquariums of different sizes. The volume of aquarium 1 is 27,000 cm^3. While Aquarium 2 has a surface area of 8000 cm^2. Find the length of each side of the aquarium. Make a comparison of the volume of the two aquariums.
		 In city A, roads are being repaired using concrete. The concrete has a volume of 1.200 m^3. The road has 240 m in length, and the width is $\frac{1}{24}$ of its length. Given this information, find the thickness of the concrete on the road! Write down your calculations!

results indicate that the instruments have accuracy, validity, and consistency in measuring students' mathematical connection abilities. This finding is in accordance with several expert opinions, which state that the main thing that becomes a measure of the

Table 3: The results of instrument test calculations.

Item Test No.	T-Value	Discriminating Power (%)	Difficulty Level	Correlation	Correlation Significance
1	2.97	47.62%	Difficult	0.642	Significant
2	6.00	28.57%	Very Difficult	0.824	Very Significant
3	3.36	38.10%	Difficult	0.800	Very Significant
4	3.29	28.57%	Very Difficult	0.786	Very Significant
5	3.62	57.14%	Difficult	0.849	Very Significant

good or bad of an instrument is determined by the validity and reliability. An instrument with good validity provides an overview of the accuracy and validity of an instrument in measuring ability or competency. Meanwhile, reliability is defined as how reliable an instrument is structured so that it can measure the ability with consistent measurement results [10, 24, 25, 29].

The study results on the calculation of discriminating power showed that items numbered 1 and 3 were in a good category, items numbered 2 and 4 were in the sufficient category and item number 5 was in the very good category. Therefore, all the items can be used to distinguish students' mathematical connection abilities well (the number of items can be seen in Table 1). The analysis of this discriminating power is essential as one of the considerations for declaring whether an instrument is suitable for use or not. Discriminating power shows the difference between groups of students who can solve problems in the questions and those who are not. Therefore, it is necessary to pay attention to the stability of discriminating power so that the instruments can distinguish groups of students who usually have different abilities from one another [28, 30].

All mathematical connection ability items arranged as instruments in this study are difficult questions [8, 10, 26, 29]. Based on interviews with teachers who teach students in grades five and six at the study site, it is known that students are not accustomed to getting questions as arranged in this instrument, so the questions presented are difficult for students to understand. In line with the teacher's opinion, students admit that the questions are tough to work on to find solutions. The questions on mathematical connection abilities that the researcher compiled are questions at the Higher Order Thinking Skills (HOTS) level. HOTS questions are usually questions with a high level of difficulty so that they are difficult for students to solve. The main cause of students' difficulty in solving problems is that students are rarely given the opportunity to solve HOTS questions. Therefore, it is necessary for teachers to familiarize students with HOTS

questions [11, 12]. Thus, when developing an instrument to measure particular abilities, it is necessary to consider expert opinions and the results of calculations regarding validity, reliability, discriminating power, and the difficulty index of the questions. This consideration will provide a solid basis for stating whether the instrument developed in the research is feasible or unsuitable for measuring particular abilities. In this study, all procedures in developing the instrument have been taken, starting from paying attention to suggestions from expert judgments to calculating validity, reliability, discriminating power, and the difficulty level of the questions. From the research, five items were developed that were suitable to measure the mathematical connection ability of fifth-grade elementary school students.

4. CONCLUSION

Based on the results and discussion, it can be concluded that the five items developed in this study have high and good validity, high reliability, and good discriminating power. Therefore, these five questions can be used to measure students' mathematical connection abilities, especially in fifth-grade elementary school. The five successfully developed questions represent three indicators of mathematical connection ability. However, the instrument developed in this study was only on geometry topics for fifth-grade elementary school students. It is hoped that further researchers can develop mathematical connection ability instruments related to other math topics at different grade levels.

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