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Spatial Sense Ability Instrument for Primary School Students

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ABSTRACT

This research is motivated by the importance of spatial sense skills possessed by elementary school students. The research aims to develop an instrument of spatial sense ability: 1) classifying real objects into 3D form; 2) investigating, exploring, and describing geometry; 3) exploring the directional relationship of objects In space; 4) analyzing the nature of 3D and interpreting into 2D forms. Research and Development as the method to investigate 33 grade VI students of SDN 1 Nagrikidul, Purwakarta Regency, West Java Province, which chosen by purposive sampling. The instrument used is an essay test consisting of seven questions regarding the geometry of cubes and blocks. The expert validated the seven questions that had been prepared. Expert considerations are used as the basic for the improvement of the compiled questions. Then the questions that have been corrected are tested on the research sample. The results of the trial were calculated for validity, reliability, difficulty index, and discriminatory power. Of the seven questions consisted of medium and difficult. Thus, 6 of the seven items develop can be used by teachers or researchers as an instrument to measure the spatial sense abilities of elementary school students, primarily fifth-grade students.

Keyword:

Elementary School Students, Spatial Sense Ability, Test Instrument.

1. INTRODUCTION

The formation of human thinking ability is one of the roles of mathematics. In practice, mathematics trains logical, critical, analytical, and systematic thinking abilities as well as collaboration. These abilities are very important because they can sharpen human critical and logical thinking skills. Student's ability to solve geometry problems is supported by cognitive skills closely related to the scope of geometry material, known as spatial ability (Fadriyah & Hendriana, 2021).

Among the higher-order thinking skills, spatial sense is one of the most critical abilities for students. Spatial sense ability is part of geometry. With spatial sense ability, one can estimate and visualize shapes and spaces in everyday life (Rahman & Saputra, 2022). Spatial sense ability is an abstract concept that includes spatial relationship, namely: 1) the ability to observe the relationship of objects in space; 2) a frame of reference such as a sign as a benchmark to indicate the position of objects in space; 3) the ability to estimate the distance between objects; 4) the ability to represent spatial relationships by manipulating them cognitively and imagining the rotation of an object in space (Mirawati & Endah, 2021)

In addition to the importance of students' spatial sense abilities, the level of these abilities is, in fact, still very low. The low ability of students' spatial sense is indicated by the low ability of elementary school students to solve geometry problems. In addition, the low ability of spatial sense in students is seen because of the ability of students to visualize a geometric problem. Generally, students find it challenging to construct geometric shapes. This condition is caused because students rarely solve geometry problems. Another factor that affects the students' low spatial sense ability is the way the teacher only teaches numbers and formulas on geometry material (Hermiati & Julianti, 2023).

Measurement of the spatial sense ability of elementary school students requires the right instrument. The instrument must refer to indicators that indicate a person's spatial sense ability. The indicators of spatial sense ability include: 1) exploring spatial relationships such as direction, orientation, and point of view of objects in space, size and shape, as well as the relationship of an object with a shadow; 2) explore the relationship of forms, such as symmetry or similarity of a shape; 3) use the properties of two- and three-dimensional shape to identify, classify, and describe shapes: 4) explore geometric changes such as rotation, reflection, and shift or translation; 5) understand and apply the concepts of symmetry and congruence; 6) identify describe, compare, and classify the geometry of planes and spaces; 7) understand the characteristics of lines and planes and the formation of angles between two lines and planes; 8) explore the relationship between congruence and geometric transformation; 9) develop, understand, and apply various ways to measure circumference, area, surface area, angle measure, and volume; 10) investigate and describe geometry in nature and its application in the real world with the help of manipulative models; 11) analyze dimensional representations of three-dimensional shapes; and 12) solve mathematical and real-world problems using geometric models (Dwi Octaviani, *et al.*, 2021; Fitriana & Lestari, 2022).

Through this study, the researchers attempted to create a set of appropriate instruments to measure the spatial sense abilities of elementary school students, especially for class V. From the indicator written in the previous paragraph, the researchers focused on developing the spatial sense ability instrument into four indicators. The four indicators referred to include: 1) being able to classify real objects into 3D form (building space); 2) being able to investigate, explore, and describe geometry in nature and the real world; 3) able to explore the directional relationship of objects in space; 4) able to analyze the nature of 3D shapes and interpret 3D

shapes into 2D forms. Hopefully, the instruments produced through this research can help teachers, parents, researchers, and other education practitioners measure the spatial sense abilities of fifth-grade students in elementary school (Schoevers, *et al.,* 2022)

2. METHODS

This research is research on developing spatial sense ability instruments, so the method used is Research and Development (R&D). The method was chosen to produce an instrument that can be used sustainably. Research and development (R&D) is research that comprises several stages. Research with this method is understood as research that begins with finding the information needed by researchers and then produces a product in the form of a model or learning device (Maydiantoro, 2021).

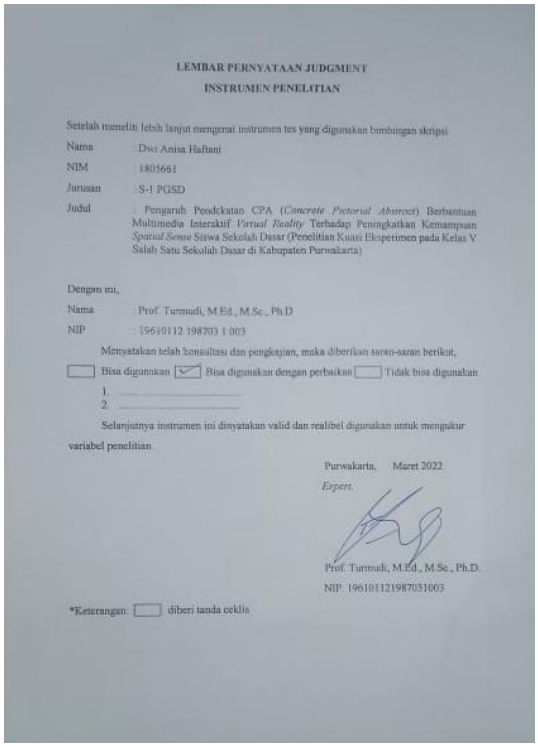
The spatial sense ability instrument developed in this study is an instrument intended for fifth-grade students in geometry material. The sample in this study was 33 grade VI students from an elementary school in Purwakarta Regency, West Java Province. The sampling technique in this study used a purposive sampling technique. With this technique, the sample is selected based on specific reasons. The reasons for selecting the sample are: 1) sixth-grade students who had received geometry material before when they were in fifth-grade elementary school; 2) the school chosen is a place where researchers teach to make it easier for licensing matters. (Lenaini, 2021).

The development of the instrument in this research went through several stages. In the first stage, the researcher developed the instrument by considering the indicators of spatial sense ability. Furthermore, expert judgment is made on the instruments that have been prepared. After making a judgment, the researcher perfected the instrument based on expert advice. Next, a spatial sense ability test was conducted on sixth-grade elementary school students to determine the instrument's feasibility. From the student test results, item analysis was carried out using the Anates application to determine the validity, reliability, level of difficulty, and discriminatory power. The results of the Anates calculation are used as the basis for determining the feasibility of the instrument made. Instruments with good or high validity, reliability, and distinguishing power will be instruments that are ready to be used to measure the spatial sense abilities of fifth-grade elementary school students (Nurwijaya, 2022).

3. RESULTS AND DISCUSSION

RESULT

This study resulted in a test instrument for the spatial sense ability of elementary school students. The indicators are based on the spatial sense ability indicators mentioned by the New Jersey Mathematics Framework (in Putri, 2017). The indicators developed in the preparation of this instrument of spatial sense ability include: 1) being able to classify real objects into 3D form (building space); 2) able to investigate, explore, and describe geometry in nature and the real world; 3) able to explore the directional relationship of objects in space; and 4) able to analyze the nature of 3D shapes and interpret 3D shapes into 2D forms. The four indicators were developed to become an appropriate instrument for spatial sense abilities. After being compiled based on indicators of spatial sense ability, the instrument is carried out by an expert judgment to one of the Mathematics Education professors for validation. The following is a statement of expert validation results.



LEMBAR PERNYATAAN JUDGMENT
INSTRUMEN PENELITIAN

Setelah meneliti lebih lanjut mengenai instrumen tes yang digunakan bimbingan skripsi

Nama : Dwi Anisa Haftani
NIM : 1805661
Jurusan : S-1 PGSD
Judul : Pengaruh Pendekatan CPA (*Concrete Pictorial Abstract*) Berbantuan Multimedia Interaktif *Virtual Reality* Terhadap Peningkatkan Kemampuan *Spatial Sense* Siswa Sekolah Dasar (Penelitian Kuasi Eksperimen pada Kelas V Salah Satu Sekolah Dasar di Kabupaten Purwakarta)

Dengan ini,

Nama : Prof. Turmudi, M.Ed., M.Sc., Ph.D
NIP : 196101121987031003

Menyatakan telah konsultasi dan pengkajian, maka diberikan saran-saran berikut,

☐ Bisa digunakan ☑ Bisa digunakan dengan perbaikan ☐ Tidak bisa digunakan

1. .....
2. .....

Selanjutnya instrumen ini dinyatakan valid dan realibel digunakan untuk mengukur variabel penelitian.

Purwakarta, Maret 2022

Expert.

Prof. Turmudi, M.Ed., M.Sc., Ph.D.
NIP. 196101121987031003

*Keterangan: ☐ diberi tanda ceklis

Figure 1. Expert Judgement Result

After the expert judgment was carried out, the instrument was revised. The results of instrument improvements based on expert advice can be seen in **Table 1**.

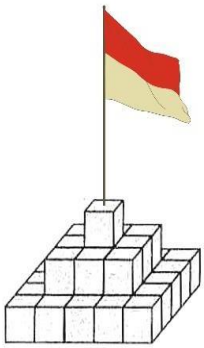
Table 1. Blueprint of Spatial Sense Ability Test

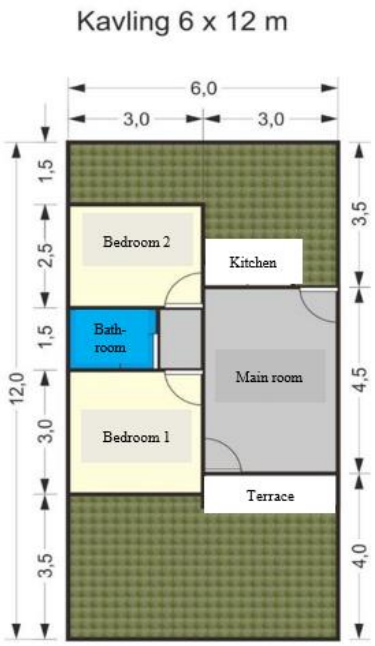
Blueprint			
No	**Indicator**	**Question**	**Alternative Answer**
1.	Able to classify real objects into 3D form (build space).	On the table are four large squares in cubes A, B, C, and D of equal size each of which has a 27,000 cm^3 volume. In each box, say box A, there are three squares of the same size and shapes as blocks. Calculate : a. What are the sizes of the small boxes in box A and what is the volume of each small box? b. How many small squares in total? What is the volume of the four large boxes on the table? And show me how you got the answer!	**Known:** Volume 1 big square = 27.000 cm^3 Big square= 4 pcs Small square = 12 pcs **Answer:** a. Size and volume of each square: Volume 1 small square = Volume of big square : 3 = 27.000 : 3 = 9.000 cm^3 Size of 1 small square: - 30 x 30 x 10 - 10 x 30 x 30 - 30 x 10 x 30 b. The number of small squares The number of small squares = The number of small squares inside big square x the number of big square = 3 x 4 = 12 small square c. Volumes of four big square

Blueprint

No	Indicator	Question	Alternative Answer
			V of four big squares = Volume of 1 big squares x the number of big squares = 27.000 x 4 = 108.000 cm^3
		On the table are four large squares, A, B, C, and D, in the form of a block of the same size. Each large square has a volume of 16,000 cm^3 with one side length of 40 cm. In each square, for example, square A, there are two squares of equal parts in the form of a cube. Calculate: a. What are the sizes of the small squares in square A and what is the volume of each small square? b. How many small squares in total? What is the volume of the four large squares on the table? And show me how you got that answer!	**Known:** Volume of 1 big square = 16.000 cm^3 One of the side length of big square = 40 cm Big square = 4 buah Small square = 8 buah **Answer:** a. Size and volume of each small squares Volume of 1 small square = volume of big squares: 2 = 16.000 : 2 = 8.000 cm^3 Size of 1 small square $\sqrt[3]{\text{Volume of small square}}$ $= \sqrt[3]{8.000} = 20$ cm Thus, the size of 1 small square is 20 cm x 20 cm x 20 cm b. The number of small squares c. The number of small squares = The number of small squares inside big squares x the number of big squares = 2 x 4 = 8 small square d. Volume of four big squares V of four big squares = Volume of 1 big squares x the number of big squares = 16.000 x 4 = 64.000 cm^3
2.	Able to investigate, explore, and describe geometry in nature and the real world.	Mom owns a pastry shop. Today she got many cheese orders from a pastry shop in the middle of town. I will send the cheese 5 cm in length	V box = 64.000cm^3 Box size = 80 cm x 40 cm x 20 cm $\frac{Box}{Cheese} = \frac{80}{5} \times \frac{40}{4} \times \frac{20}{4}$ $= 16 \times 10 \times 5$ $= 800$ *cheese slices*

Blueprint

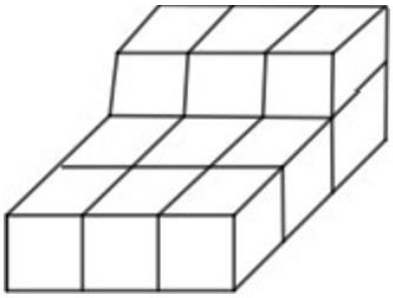
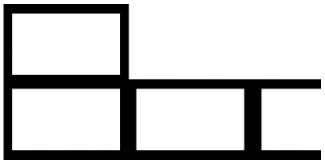
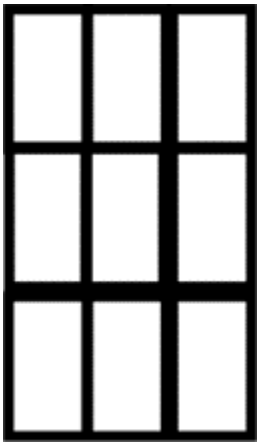
No	Indicator	Question	Alternative Answer
		 4 cm in width, and 4 cm in height. The cheese will be put in a box as a block with a volume of 64,000 cm3. One of the ribs is 80 cm long. How many slices of cheese do you have to prepare to fill the box, so it is completely filled?	
		The arrangement of the cubes without gaps forms the foundation of the flagpole, as shown in the following figure.  The outside of the foundation is painted yellow and then separated one by one. How many cubes have three yellow sides? Why?	The number of cubes whose three sides are yellow is 8 pieces. - The right side, the top, and the front which are yellow: 2 pieces - The left side, the top and the front are yellow: 2 pieces - The right side, the top, and the back are yellow: 2 pieces - And the left, top, and back are yellow: 2 pieces.

Blueprint			
No	**Indicator**	**Question**	**Alternative Answer**
		Tina's parents are going to buy a house lot. They found a house with the following designs and size.  They plan to buy a simple house with a high enough ceiling of at least 3.5 m. a. If the volume of the living room is 54 m^3, what is the room's ceiling height? Is it according to the wishes of Tina's parents? b. If all the ceiling heights of the room are like your answer in the previous question, then Room 1, Room 2, and Central Room resemble what kind of room?	a. V main room = l x w x h h = V : (l x w) h = 54 m^3 : (4,5 m x 3 m) h = 54 m^3 : 13,5 m h = 4 m The height of the living room is according to the wishes of Tina's parents. b. Bedroom 1 = cuboid Bedroom 2 = cuboid Main room = cuboid

Blueprint

No	Indicator	Question	Alternative Answer
3.	Able to explore directional relationships of objects in space	 Jalan Anggrek 400 m Jalan Merdeka 1.000 m Jalan Kusuma 800 m Jalan Dahlia 200 m Jalan Mawar 200 m	
		Pak Ali is at his house, which is located east of the market. He wanted to teach swimming lessons. Mr. Ali had to ride his motorbike to go to the tutoring place. a. Sort of the path that Mr. Ali uses. If every 1 km consumes 0.5 liters of gasoline, how much gasoline does Mr. Ali spend on the way to the tutoring site? Please show me how you got it.	a. The roads that Mr. Ali uses are Jalan Mawar, Jalan Merdeka, and Jalan Anggrek b. Every 1 km consumes 0.5 gasoline, 1 km = 1.000 m Jl. Mawar= 200 m Jl. Merdeka= 1.000 m Jl. Anggrek which is used = length of Jl. Anggrek – Jl. Mawar = 400 m – 200 m = 200 m Distance = Jl. Mawar + Jl. Merdeka + Jl. Anggrek = 200 + 1.000+ + 200 = 1.400 m Used Gasoline = $\frac{distance}{1.000\ m}$ x Liter/km = $\frac{1.400}{1.000}$ x 0.5 = 1,4 x 0,5 = 0.7 Liter

Blueprint

No	Indicator	Question	Alternative Answer
4	Able to analyze the nature of 3D shapes and interpret 3D shapes into 2D forms	 The shapes above is an arrangement of blocks of the same size and shape. Draw the shape when viewed from the top and left sides	View from the left side  View from the front side 

The instruments in **Table 1** have been compiled based on improvements from expert judgments consisting of 7 questions and then tested on 33 grade VI elementary school students who became the research sample. After being tested, the seven questions entered the item analysis stage to see the validity, reliability, discriminating power, and level of difficulty of each question. In detail, the results of the item analysis of this test instrument are described in **Table 2** below.

Table 2. The results of item test analysis

Item Number	T	Discriminating power (%)	Difficulity Level	Correlation	Correlation significance
1	3.95	40.74	Medium	0.578	Significant
2	7.07	55.65	Difficult	0.711	Very Signficant
3	3.29	37.04	Medium	0.579	Significant
4	12.50	92.59	Medium	0.831	Very Significant
5	3.83	48.15	Medium	0.642	Significant
6	6.43	62.96	Medium	0.844	Very Significant
7	2.37	25.93	Difficult	0.377	Insignificant

Based on the results of the analysis, it is concluded that the overall correlation calculation results are 0.69, and the test reliability is 0.82. The conclusion shows that the questions on the spatial sense ability instrument have high validity (0.69) and reliability values (0.82).

3. DISCUSSION

This ability is one of the abilities that students must possess. The ability of spatial sense is included in one of the eight multiple intelligences. These multiple intelligences include linguistics, logical mathematics, spatial, physical kinesthetic, musical, intrapersonal, interpersonal, and naturalist. Spatial sense ability is a person's ability to represent and recognize spatial shapes in everyday life (Hikmawati, *et al.,* 2022).

The level of spatial sense ability in its implementation can be seen in the students' ability to solve geometric problems. The Trends in International Mathematics and Science Study (TIMSS) analysis shows that the ability to solve geometry problems for Indonesian elementary school students is still deficient (Kusuma, *et al.,* 2022). In addition, students' ability to understand geometric concepts such as spatial configuration and the ability to interpret plane representations also failed. Thus, the ability of spatial sense among elementary school students is still considered low (Sari, *et al.,* 2021). Spatial ability has two virtues that are considered, namely in spatial ability there is spatial orientation and spatial visualization, while in the education system at school, geometry material is one of the mathematics materials that are difficult for students to learn because students are required to have mathematical resilience skills where students must be able to maintain their answers to the understanding of the material that has been given.

The questions of the spatial sense ability test instrument developed in this study fall into the medium and difficult levels. Looking at the discriminatory power of all the questions, one of them is classified as a low category with a discriminatory value of only 25.93%. Thus, of the seven items that were compiled, 6 of them were considered suitable to be used as an instrument for testing the spatial sense ability of elementary school students. Teachers in the classroom can also use the test instruments produced in this study as an effort to improve students' spatial sense abilities. In addition, this test instrument can be used by other researchers who want to examine the spatial sense abilities of elementary school students.

4. CONCLUSION

The analysis results of the spatial sense ability test instrument compiled in this study have a high validity value of 0.69. In addition, the test reliability value of this instrument is also relatively high, with a value of 0.84. Although the discriminatory power of the seventh item showed a low value, the 6 test instrument items produced in this study were declared valid and reliable, had high discriminatory power, and the difficulty level of the questions fell into the medium and difficult categories. Thus, 6 of the seven items developed in this study were declared eligible to be used. This test instrument can be used by 1) teachers to improve the spatial sense abilities of elementary school students and 2) other researchers who desire to examine spatial sense abilities in elementary schools. The indicators of the six items that were declared valid were: 1) able to classify natural objects into 3D form (building space); 2) able to investigate, explore, and describe geometry in nature and the natural world; and
3) able to explore the directional relationship of objects in space

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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