Spatial sense instrument for prospective elementary school student

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Abstract. In order to produce high-quality research, the good instrument is required. The instrument developed in this study was a spatial sense test instrument. The test items were based on indicators of spatial sense. After prepared the test items then tested to determine the validity, reliability, level of difficulty and distinguishing power. The results show that the questions were compiled for this study generally has a high validity, reliability is very high, distinguishing power for each items is well, and the questions are divided by varied level difficulty (easy, medium and difficult). Based on this result, it can be concluded that the spatial sense test items that developed can be used as a test instrument for future research.

1. Introduction

Problems in this study motivated by the expectation that the written curriculum in research by Committe in the Undergraduate Program in Mathematics (CUPM) [1] explains that one of the recommendations that each course in mathematics should be an activity that will assist students in the development of analytical ability, critical reasoning, problem solving, communication and mathematical representations. Correspondingly, based on Government Regulation Number 16 of 2007 is written that a teacher must have professional competence, that teachers are expected to master the conceptual and procedural knowledge and link ages both within the context of the material arithmetic, algebra, geometry, trigonometry, measurement, statistics, and mathematical logic. Therefore, the Institute of Higher Education Teacher charge generating prospective elementary school student responsible for preparing students for the professional competence that one way is to strength then the mathematical ability. The one of expected mathematical ability from students is the spatial sense.

Furthermore, Rosenstein [2] states that all students are expected to develop spatial sense and the ability to use geometric properties and relationships to solve problems in mathematics and everyday life. In line with the second statement, Bennie and Smit [3] states that no spatial skills would be difficult to exist in the world, for example, without spatial ability, we will unable to communicate about the position and the relationship between objects, give and receive directions and imagine the changes in the position or size of the shape.
To measure student ability level in spatial sense, it is necessary the appropriate evaluation tools. One of evaluation tool that can be developed and used to measure spatial sense ability is as test instruments. Based on the above mentioned problems, the researchers were interested in doing a test instrument to measure the progression of student spatial sense ability from prospective elementary school student.

To measure the ability of spatial sense required a clear indicator. Rosenstein [2] mentions 27 indicators of geometry and spatial sense, namely: 1) Exploring spatial relations such as direction, orientation, and the perspective of the object in space, shape and relative size of them, and the relationship between object shadow or projection; ... 27) explores other geometry in the context of the application in the real world. From the various things about the ability of spatial sense that has been presented, it can be concluded that the indicator of the spatial sense ability in this research that the student can: exploring spatial relationships such as direction, orientation, and the perspective of objects in space, and the relationship between the object and its shadow or projection; Understand, implement and explore the relationship between shape, such as harmony, symmetry, and similarities, and congruence; Using the properties of three and two-dimensional shapes to identify, classify, and describe shapes; Explore geometric transformations such as rotation, reflection, and translation; Develop, understand, and apply a variety of strategies to determine the perimeter, area, and volume; Solve mathematical and real-world problems using geometric models.

2. Research method
The method used in this research is the Research and Development (R&D). Selection of research method is based on research objectives to generate appropriate instrument for further research. This opinion is in line with the opinions Sugiyono [4] states that "The method of research and development is a research method that used to produce a particular product, and test the effectiveness of these products."

This study was conducted on 27 students of prospective elementary school teachers of mathematics concentration at semester 5 which has been taking courses in mathematics education 2, at UPI Purwakarta. The results of calculations later in the analysis based on certain criteria. Validity interpreted based classification validity coefficient by Guilford [5] as follows:

| Value $r_{xy}$ | Interpretation       |
|----------------|----------------------|
| 0.90 < $r_{xy}$ ≤ 1.00 | Very high (very good) |
| 0.70 < $r_{xy}$ ≤ 0.90 | High (good)          |
| 0.40 < $r_{xy}$ ≤ 0.70 | Intermediate (enough) |
| 0.20 < $r_{xy}$ ≤ 0.40 | Low                  |
| 0.00 < $r_{xy}$ ≤ 0.20 | Very low             |
| $r_{xy}$ ≤ 0.00       | Not valid             |

Reliability interpreted based classification reliability coefficient by Guilford [6]:

| Value $r_{11}$ | Interpretation |
|----------------|----------------|
| $r_{11}$ ≤ 0.20 | Very low       |
| 0.20 < $r_{11}$ ≤ 0.40 | Low            |
| 0.40 < $r_{11}$ ≤ 0.60 | Intermediate   |
| 0.60 < $r_{11}$ ≤ 0.80 | High           |
| 0.80 < $r_{11}$ ≤ 1.00 | Very high     |

Classification for distinguishing interpretation used by the classification according To [7], namely:
Table 3. Classification for distinguishing.

| Classification | Interpretation                  |
|----------------|---------------------------------|
| Negative - 10% | Very bad, must be removed       |
| 10% - 19%      | Bad, will be better if removed  |
| 20% - 29%      | Almost good, probably need to be revised |
| 30% - 49%      | Good                            |
| 50% to the top | Very good                       |

Level of difficulty about the interpretation used by the classification according To [7], namely:

Table 4. Classification to the level of difficulty.

| Classification | Interpretation |
|----------------|----------------|
| 0% - 15%       | Very difficult |
| 16% - 30%      | Difficult      |
| 31% - 70%      | Intermediate   |
| 71% - 85%      | Easy           |
| 86% - 100%     | Very easy      |

3. Results and discussion

3.1. Result

The result of this research is a sense of spatial ability test instrument. The spatial sense ability indicators used to compile the test instrument refers to Rosenstein [2], namely: exploring spatial relationships such as direction, orientation, and the perspective of the object in space, shape and relative size of them, and the relationship between the object and its shadow or projections; Using the properties of three and two-dimensional shapes to identify, classify, and describe shapes; Explore geometric transformations such as rotation (rotation), reflections (flips), and translation (slide); Understand and apply the concept of symmetry, similarity, and congruence; Identify, explain, compare, and classify geometric plane and space; Understanding the properties of lines and planes, including a line (plane) parallel and perpendicular and the line (plane) intersect and the formation of the angle between two lines or fields; Develop, understand, and apply a variety of strategies to determine the perimeter, area, surface area, size of the angle, and volume; Analyzing the nature of three-dimensional shapes by drawing and building models and interpretation two-dimensional representations of three-dimensional shapes; Solve mathematical and real-world problems using this geometrics. The following are lattice and the test instrument used in this study, subject: Mathematical education II; Topic: Two and three-dimension form; Study program/semester: Prospective elementary school student program/IV (four):

Table 5. Lattice of spatial sense test item.

| No | Indicator                                                                 | Test Item                                                                                                                                                                                                 |
|----|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Students can understand and apply the concept of symmetry, similarity, and congruence to determine the area of the square. | In the picture below, there are two large square with sides of length congruent 7 units and four small square that are congruent with the long side 3 units. If the images are shaded in a large square is also a rectangle, how many unit squares extent? |
| 2  | Students can analyze the properties of three-dimensional form with drawing and building models and interpret two-dimensional representations of three-dimensional form. | Look at the picture below.                                                                                                                                                                                                 |

Sketch a picture of cube above by constructing a model of two-dimensional representation, when viewed from different angles(from the top, front, and side)!
Table 5. Cont.

|   | Students can use properties of the three-dimensional and two dimensions’ form to describe the shape. | Draw a picture of cube of the nets below! |
|---|-------------------------------------------------------------------------------------------------|------------------------------------------|
| 3 | Students can identify, compare, and classify geometric field.                                  | From the image below, the two images are congruent pair is...... |
| 4 | Students can explore the relationship between geometric transformations (rotation).              | If the picture on the side rotated 90° wise so far, make images of the results of the rotation! |
| 5 | Students can understand the properties of lines and planes as well as the formation of the angle between two lines or fields. | Look at the picture below. |
| 6 | Explore spatial relationships such as direction, orientation, and the perspective of the object in space, the shape and size of their relative, and the relationship between the object and its shadow or projection. | 
| 7 | Students can apply a variety of strategies to determine the surface area of a flat form.       | Determine the angle DEF! |
| 8 | Students can solve math problems using geometric models.                                       | Look at pictures of office complex map below. |
| 9 | Students can solve real-world problems using geometric models.                                  | Ana walks from building A and move in the following order: to the left into Jalan Gatot Subrototo the east, at the first intersection turn left towards the north, and at the second junction turn right towards the east. What building is the Ana’s target? |
| 10| Students can solve the real-world problems using geometric models.                             | 

Ten questions on the next item is tested against 27 students who are not subject to research, to see the validity, reliability, distinguishing interpretation, and level of difficulty for each item. Tests performed using the program Anates 4.0. Result show to mean of all item= 72,56; Standard deviation= 25,92; Correlation= 0,73, Reliability test = 0,84; Item test = 12; Number of Subject = 27. Here are presented table test results about each item.
Table 6. Results of the calculation testing of instrument for spatial sense ability.

| Number of item | t test | Distinguishing power interpretation | level of difficulty | correlation | Significant of correlation |
|----------------|--------|------------------------------------|--------------------|-------------|---------------------------|
| 1              | 8.59   | 85.71 %                            | Intermediate       | 0.598       | Significant               |
| 2              | 5.52   | 82.86 %                            | Intermediate       | 0.562       | Significant               |
| 3              | 4.69   | 62.86 %                            | Easy               | 0.517       | Significant               |
| 4              | 4.58   | 50.00 %                            | Easy               | 0.590       | Significant               |
| 5              | 3.87   | 50.00 %                            | Easy               | 0.532       | Significant               |
| 6              | 2.77   | 52.86 %                            | Difficult          | 0.552       | Significant               |
| 7              | 2.47   | 47.14 %                            | Difficult          | 0.528       | Significant               |
| 8              | 2.20   | 38.57 %                            | Easy               | 0.534       | Significant               |
| 9a             | 3.36   | 57.14 %                            | Easy               | 0.654       | Very Significant          |
| 9b             | 4.90   | 57.14 %                            | Intermediate       | 0.556       | Significant               |
| 10a            | 5.63   | 45.71 %                            | Easy               | 0.760       | Very Significant          |
| 10b            | 3.42   | 68.57 %                            | Intermediate       | 0.592       | Significant               |

3.2. Discussion

Spatial sense is an intuitive feeling for form and space. This involves the concept of traditional geometry, including the ability to identify, visualize, represent, and changing the geometric shape [2]. The ability of spatial sense on two levels, namely the low-level capabilities are capabilities that require visualization of two-dimensional configuration, but no mental configuration of visual images and a high level of ability is an ability that requires visualization of three-dimensional configuration, and there is the mental manipulation of visual images [8].

Spatial sense of ability is part geometry capabilities. Connectedness geometry and spatial sense capabilities described by Braconne and Marchand [9] which stated that geometry, especially three dimensional forms can improve spatial sense. Furthermore, Bennie and Smit [3] stated that there is a connection between spatial sense and performance in geometry and mathematics in general. The importance of spatial sense understanding of the students described by [10] which states mathematics instruction program should pay attention to geometry and spatial sense, so that students can use visualization and spatial reasoning to solve problems. Meanwhile, the research results of Malati [11] reveal that many students fail in the fourth and fifth aspects of spatial sense. The fourth aspect is the ability to represent the spatial configuration of the image field and the fifth aspect is the ability to interpretation the representation of the field of spatial configuration.

Based on the results of this research is that the problems that made the overall test has high validity value that \( r_{xy} = 0.73 \) (based on the validity of the interpretation of the correlation coefficient expressed [5]). High reliability is \( r_{11} = 0.84 \) (interpretation of reliability is based on the correlation coefficient expressed in [6]). Problem is divided into easy matter, medium, and high (interpretation of the level of difficulty of questions based on the coefficient index about the difficulty of [7]). Different power in general about the good and excellent (interpretation of the level of difficulty of questions based on the difficulty index coefficient matter of [7]). Thus, a matter which made listed on lattice problems can be used as a test instrument to measure the ability of spatial sense elementary student teachers.

4. Conclusion

The study to develop a spatial sense instrument for prospective elementary school student was conducted comprehensively. This study was conducted on 27 students of prospective elementary school teachers of mathematics concentration at semester 5 which has been taking courses in mathematics education 2, at UPI Purwakarta. Test instruments in the form of questions that have been made in the table lattice problems, all of which can be used to measure the ability of spatial sense prospective elementary teachers.

Acknowledments

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