El-Aulad: Jurnal Pendidikan Dasar
Volume 01, Nomor 01, 2024

What is the Spatial Ability Profile of Elementary School Students in Solving Geometry Problems?

Ali Fikri Mubarok[1], Millatul Islamiyah[2]
[1]Kajian Anak Islam Intensif (KAIFA) Doha, Qatar
[2]Sekolah Tinggi Ilmu Tarbiyah Miftahul Ulum Bangkalan, Indonesia
email correspondence: mf2202269@qu.edu.qa

Abstract

Spatial ability is included in the category of subjects that are important to master elementary school students, especially mathematics subjects. The fact that students' level of mathematical ability, especially spatial ability, is still relatively low is inevitable. The cause of students' low mathematical ability, one of which is abstract mathematical characteristics, for example in geometry material. This type of research is descriptive qualitative. The method used in this study is the study of literature. This study aims to collect as much literature as possible to explore the study of spatial ability profiles of elementary school students with content analysis techniques. The results of this study show that students' low spatial ability can be influenced by strategies and higher-order thinking skills.

Keywords

Student profile, geometry, spatial capabilities, primary school mathematics

INTRODUCTION

Mathematics is one of the crucial subjects for elementary school students to learn because this subject (maple) is one of the maples tested in the exam national annually. In addition, mathematics is also very useful to help students in the practice of daily life because life outside the school environment is also inseparable from the aspect of mathematics. In Indonesia, test and evaluation results from 2003 to 2018 conducted by the Programme for International Students Assessment (PISA) reported that the average score of mathematical ability was still low, with scores of 386 (2015) and 379 (2018). The average mathematics score released by the OECD for mathematics is 489, so the scores of Indonesian students are still far below the average (OECD., 2019). Based on the analysis of PISA study results, Indonesian students are weak in understanding space and form. In one of the geometry questions in the PISA study according to Kariadinata (2010), only 33.4% of Indonesian students were able to answer correctly, and the remaining 58.79% answered incorrectly. (Prakoso, Putra, Mentari, &; Rahman, 2015). This is in line with research conducted by (Wardhani, 2011) that in general students have difficulty in visualizing and constructing geometric spaces.

Material in learning mathematics in elementary schools is presented systematically and sequentially, starting from simple concepts to more complicated ones. The National Council of Teachers of Mathematics (NCTM) (Loeber, 2008; Ulfah &; Felicia, 2019) provides mathematical content standards, consisting of 1) numbers and their operations, 2) algebra, 3) geometry, 4) measurement, 5) data analysis and probability. These five content standards apply to grades Prekindergarten through grade 12 but with different

weights and emphases in each class. Geometry is one of the mathematical content standards based on NCTM. (Runtukahu & Kandou, 2014) geometry is derived from the Greek languages, ge and metrein. Ge means earth and metrein means measure. In ancient times, geometry was used to measure the earth. When making pyramids and measuring soil, the ancient Egyptians used geometry. In today's world, geometry is the science or study of building flats and building spaces and their relationships.

According to NCTM, the topics of geometry and measurement are separate sections. This shows the importance of geometry and measurement as a topic that should be incorporated into the primary and secondary curriculum. Elementary schools in Indonesia are no exception that apply the 2013 curriculum at this time, in the curriculum the concepts of geometry and measurement are given as stated in the 2016 Permendikbud regarding the core competencies and basic competencies of elementary/MI mathematics. Geometry is a topic that must be studied in elementary school because according to (Sopiany & Rahayu, 2019) among various branches of mathematics such as, Calculus, Algebra, Geometry, Statistics, and so on. In the branch of geometry that touches almost all aspects of our lives. In the surrounding environment, we often find buildings that resemble geometric shapes such as wall clocks, house doors, drink bottles, wardrobes, milk cans, and so on.

Problem-solving in elementary schools is usually presented by teachers in the form of practice questions both in the material book and in student worksheets. With the practice questions, students will practice to find problems from the problems which will then think about plans or processes to get solutions for the right solution. In problem-solving, each student is different in the process of finding a solution. It also depends on the student's understanding of the problem that has been presented. Runtukahu & Kandou (2014) suggest that there are two types of mathematical problem solving, both consisting of; 1) Routine problem solving or abstract problems. Routine problem-solving is better known as story problems. Because the questions in this type resemble the types of real questions. For solving this type of problem, students can solve it using almost the same mathematical method as explained or delivered by the teacher. This type of problem-solving is also more common in textbooks because problem-solving in textbooks is an abstract problem. 2) Nonroutine troubleshooting or real troubleshooting. Form problems on nonroutine problems or real problems in the form of mathematical problems that exist in the real world or real mathematics. So, the problem starts from a real situation and to solve the problem can use mathematical modeling in translating the problem, and then the problem is returned to the real world problem. In choosing a resolution procedure, non-routine problems require higher thinking when compared to routine problem-solving.

In solving geometry problems in elementary school, of course, a problem-solving strategy skill is needed. The strategies used by students for problem-solving are also very diverse. In general, a commonly used problem-solving strategy is the Polya method. The model of solving problems with the Polya method consists of four stages. Runtukahu & Kandou (2014) describe the 4 stages of Polya as follows: 1) understanding the problem, 2) making a solution strategy plan, 3) implementing the chosen strategy until finding an answer, and 4) answer testing. In addition, solving geometry problems requires good spatial skills. This is because in solving geometry problems it is not enough just to apply the rules to solving problems, but must be able to think abstractly about the geometric

objects intended in the problem. In the development of new education, abstract thinking skills are one of the skills that occupy the forefront. In this perspective, one such skill is spatial ability as explained by Yıldız, Özdemir (Özdemir et al., 2015) "Spatial ability has an extra important place in education". Thus, to abstract the shapes of these geometric objects in our minds require an ability called spatial ability.

Spatial ability is closely related to geometry. Turgut & Yilmaz (2012) suggest the importance of spatial thinking skills as a way to understand geometry "ability of visual thinking is an important way to understand the geometry and mathematics". It is in accordance with NCTM (Lowrie et al., 2016) that spatial reasoning supports an understanding of our geometric world. Such spatial reasoning allows us to direct our environment, position furniture in rooms, and visualize diagrams when solving mathematical problems. In addition, according to Maier (1996), spatial abilities can be used more widely, which can help someone with everyday life problems such as in the field of work. So, spatial skills are not only needed to solve geometry problems, nor in biology, physics, and chemistry subjects. So important is this spatial ability that all of us, especially teachers, are required to pay more than enough attention so that spatial abilities are taught seriously in accordance with the mandate of the curriculum.

METHOD

The method used in this study is the study of literature. Data collection techniques are carried out by documentation techniques and data analysis using *content analysis methods* (Fraenkel &; Wallen, 2012). This literature research method is used to compile concepts regarding the spatial ability of elementary school students in solving geometry problems.

DISCUSSION

Spatial Ability

In everyday life, the word "ability" is commonly used both in speech and in scientific discussions. So in its exact definition, it is rarely explained. Carroll (2005) suggests the definition of capability is "...it is a word that *seems to be accepted as a sort of conceptual primitive, and in fact, it is intimately related to such commonly used words as able and the simple modal auxiliary can. it is sometimes used to characterize material objects*...", meaning that the word "ability" is in fact closely related to commonly used words such as the word "capable" which refers to a person's cognitive, But sometimes the word "capable or ability" can also be used on material objects or objects, such as in the sentence "the drink bottle is able to hold as much as 600 ml of water".

Spatial ability is a combination of the words "ability" and "spatial". Thus, to understand the understanding of spatial ability, the understanding of ability and spatial will be described first. Ability according to the Big Indonesian Online Dictionary (Education &; Indonesia, 2016) comes from the basic word "capable" which means ability, ability, and strength. The word "spatial" in KBBI Online has a meaning regarding space or place. Thus, in simple terms, spatial ability can be defined as a person's proficiency in the spatial field.

The use of the word ability is often used in various ways, so as not to overlap, the definition needs to be limited. Carroll (2005) provides limitations in defining general abilities with regard to all sorts of tasks, but especially those of the cognitive or intellectual

type, such as intelligence. Specific abilities relate to the type of task specified. Each specific ability must, even if possible be defined in such a way that it does not overlap with other special abilities.

According to Subroto (2012) spatial ability plays an important role in understanding geometry because spatial ability is closely related to spatial analysis, position prediction, and illustration. This statement is in accordance with the opinion expressed by NCTM that spatial reasoning or ability supports our understanding of the geometric world. Spatial abilities fall into the category of abilities found in the realm of psychology because this ability is a reference for people in entering the field of work or profession through psychological tests. Therefore, Subroto (2012) defines spatial ability as a mental process in perceiving, storing, remembering, creating, changing, and communicating spatial builds. A person needs higher-order thinking to perform such activities or mental processes.

According to Cantürk-Günhan et al., (Turgut & Yilmaz, 2012) the use of the term spatial ability between researchers and other researchers varies, "*In the existing literature, the terms spatial ability, spatial skills, visualization ability, visual-spatial ability, spatial perception, spatial conceptual ability, three-dimensional visualization, visual cognition and ability of visualization are used interchangeably*". There are researchers who call it spatial reasoning, spatial skills, and visual-spatial abilities. Due to differences in the use of the term spatial ability, the definition and division of spatial ability components will also be different.

The difference in the use of the term spatial ability was also conveyed by other researchers. NCTM, Olkun, D'Oliveira (Özdemir et al., 2015) provide an explanation of the different uses of the term. Some concepts such as spatial thinking, spatial perception, and spatial reasoning are used instead of the term spatial ability. It can be said that this difference comes from discussing spatial abilities from different perspectives "*Different definitions of spatial ability, and presenting components in different numbers and names provided by different researchers*". That is, although the use of different terms in defining spatial abilities have diversity. The existence of differences among researchers can be explained by reason, different definitions of spatial ability, and presenting components in different numbers and names given by different researchers.

The definition of spatial ability according to Olkun, Turgut, Hegarty & Waller (Sevda Göktepe Yildiz & Özdemir, 2017) is *"a combination of some skills, such as imagining the objects from different perspectives, moving objects in the mind, mental rotation, visualizing 2D and 3D geometric figures*". This means that spatial ability is a combination of several skills, such as imagining objects from different perspectives, carrying out the movement of objects in the mind, mental rotation, two-dimensional visualization and three-dimensional geometric shapes. So it can be concluded that when students use spatial abilities, the student can imagine the rotation, movement of an object, and is able to imagine objects from different perspectives and can manipulate the object in his mind. Linn and Petersen (Sevda Goktepe Yildiz & Ozdemir, 2020) define spatial ability as "*skill in representing, transforming, generating, and recalling symbolic, nonlinguistic information*". That is, spatial ability refers to skills in representing, transforming, generating, and recalling symbolic and non-linguistic information.

Lohman (Turgut & Yilmaz, 2012) defines spatial ability as "*generate, retain, retrieve and transform well-structured visual images*". Spatial ability can be defined as the ability to

produce, store, retrieve, and transform well-structured visual images. Meanwhile, according to Kayhan (Turgut & Yilmaz, 2012), spatial ability is "*... ability to manipulate, reorganize or interpret relationships visually*". That is, spatial ability is the ability to manipulate, rearrange or interpret visual relationships.

The spatial ability in question (see Table 1) in this study is a mental activity in manipulating or transforming objects, imagining objects from different perspectives, and solving mental rotation problems quickly. The whole activity takes place in the mind. The results of mental activity can be seen when students are able to solve problems related to determining or creating spatial images by manipulating or transforming objects, rotating objects, and displaying objects from different points of view.

Table 1. Indicators of Spatial Ability of Primary School Students (adaptation of Lowrie et al., 2016)

Component	***Indicators***
Spatial Visualization	Manipulate or transform spatial pattern images to form other visual shapes.
Mental Rotation	Solve the problem of mental rotation quickly, without imagining the position of the observer self.
Spatial Orientation	Understand and engage with the relationship between the position of objects as they relate to the position of the observer.

Troubleshooting

Problems will always color human life throughout his life, based on the fact that almost everyone has problems in his life. A problem is something that blocks that needs to be solved, but the way or procedure for solving it is not yet known. The problem according to (Maier, 1996) is "a *problem exists when an individual has a goal but does not know how to immediately reach the goal*". That is, "there is a problem when a person has a goal but does not know how to immediately achieve that goal".

Problems in mathematics are divided into two, consisting of routine problems and non-routine problems. (Runtukahu & Kandou, 2014) suggests that there are two types of mathematical problem solving, both consisting of; 1) Routine problem solving or abstract problems. Routine problem-solving is better known as story problems. Because the questions in this type resemble the types of real questions. For solving this type of problem, students can solve it using almost the same mathematical method as explained or delivered by the teacher; 2) Non-routine problem-solving or real problem-solving. Form problems on non-routine problems or real problems in the form of mathematical problems that exist in the real world or real *mathematics*.

According to Polya (2004), there are two mathematical problems, as for the two mathematical problems as follows. First, *Problem to find*. The purpose of "problem *to find*" is to find, determine, or obtain certain values or objects that are asked in the problem or question and meet the conditions or conditions that are in accordance with the problem. Object asked or searched (*unknown*), conditions that meet the problem (*conditions*), and the information or data provided is an important part of a problem *to find* so it must be understood and recognized well at the beginning of solving the problem. Second, problem

to prove. The purpose of a "*problem to prove*" is to show convincingly, unequivocally, and clearly that the statement is true or that the statement is false."*Problem to prove*" consists of the part of the hypothesis and the conclusion of the theorem that must be proved. The proof is done by making or processing logical statements from hypotheses to conclusions, while to prove that a statement is not true, it is enough to give an example of the refutation so that the statement is not true (Lee, 2016).

Based on the mathematical problem proposed by Polya (2004), the problem used in this study is a "problem to find" because students will be given the task of geometry problems to find or determine changes in the shape of 2-dimensional and 3-dimensional shapes that are not yet known so that students must be able to recognize and understand objects in the problem. In problem-solving, everyone may have different strategies from one person to another. In general, a commonly used mathematical problem-solving strategy is the Polya method. The model of solving problems with the Polya method consists of four stages. (Runtukahu & Kandou, 2014) describes the four stages of Polya as follows:

- Understand the problem: Identify what to look for and ask about the problem by identifying the condition of the problem. You can ask yourself some things, such as what is known, what is unknown, what is the relationship between what is known and what is unknown, what is asked, and others. So that the problem can be well understood.
- Make a problem-solving plan: At this stage, students create or choose a strategy from several strategies that have been thought out based on the facts of the conditions available in the problem and make an estimate of the solution to the problem.
- Implement the completion plan: Implement the strategy chosen in stage 2 until an answer is found.
- Checking back: The last step of the Polya method is to re-examine the answer to check whether the answer is in accordance with the problem presented.

The importance of problem-solving in mathematics is that training higher-order thinking skills according to Gagne (Gagné & White, 1978) can be improved through problem-solving. This opinion is relevant to the learning theory that has been developed by Gagne.

The type of learning that is the highest level and most complex compared to other types of learning is problem-solving. According to Wilson (2013), problem-solving in mathematics is an important part, "*problem-solving has special importance in the study of mathematics*". That is, problem-solving has special importance in the study of mathematics. Furthermore, Wilson, et al., also revealed that for many people who understand mathematically, mathematics is synonymous with solving problems, doing word problems, making patterns, interpreting numbers, developing geometric constructions, proving theorems, and so on. On the other hand, people who are unhappy with mathematics may describe mathematical activity as a problem.

Geometry Problems in Elementary School

The mathematics content standards based on NCTM are "Content Standards for Pre-K12 Mathematics: Number and Operations, Algebra, Geometry, Measurement, Data Analysis and Probability". The content standards of the five learning topics have different

learning emphases at each grade level. Based on NCTM (Putri et al., 2020; Ulfah & Felicia, 2019) the content standard in the geometry chapter is to further emphasize the broader view and power of geometry that students have in analyzing the characteristics of geometric shapes and making mathematical arguments about geometric relationships, as well as using visualization, spatial reasoning, and geometric modeling in solving problems.

According to Clements and Battista, Bishop (Kovačević, 2017), spatial reasoning is directly part of a geometry curriculum, emphasizing in that way a strong relationship between spatial reasoning and school geometry had/have". That is, spatial ability or spatial reasoning is part of the geometric curriculum emphasized in such a way that it will make a strong relationship between spatial reasoning and geometry that has been or exists in school. Elementary school age is the most appropriate age to train students' spatial skills. This is in line with the opinion of Bosnyak & Nagy-Kondor (2008) that spatial skills must be trained from an early age. The development of spatial abilities should begin at an early age of children. Spatial representation conventions can be taught effectively at ages 9-12.

In the 2013 Curriculum applied in Indonesia, geometry is one of the materials taught from grade 1 to grade 6. Geometry is a standard of mathematics subject content contained in core competence 3 (knowledge) and core competence 4 (skills). The topic of learning geometry is contained in the basic competencies in each content competency. Each basic geometry competency has different levels of material and objectives at each grade level. Table 2 is geometry material studied in elementary schools, especially in grade 5 based on the 2016 Minister of Education and Culture.

Table 2. Basic Competencies in Class V Related to Spatial Abilities

Basic competencies	***Basic competencies***
3.6 Explain and find webs of building simple spaces (cubes and blocks)	4.6 Create webs of simple space constructs (cubes and blocks)

Based on the basic competence of grade 5 mathematics on geometry material, the material studied is cubes and blocks. Thus the task of spatial ability in solving geometry problems in this study is a geometry problem related to cubes and blocks. In fact, it is suspected that there are still many students who have difficulty in doing geometry problems that involve spatial skills. According to Ryu, Chong, & Song (2007) from some of the research results described, it was found that some students have difficulty in imagining spatial or 3-dimensional objects from flat or 2-dimensional representations. The *National Council of Teachers of Mathematics* (NCTM) lays out the standards and expectations of grades 3-5 in the 4th geometry standard, allowing all students to use visualization, reasoning concerning space, and geometric models to solve problems. The expectation of this standard in grades 3-5 that is in line with KI and KD in the 2013 grade 5 curriculum is that students must mentally create and draw images of objects, patterns, and trajectories, identify and create three-dimensional objects from two-dimensional object drawings, and identify and create two-dimensional images of three-dimensional objects.

CONCLUSION

Based on the description above, it can be seen that the topic of geometry studied in grade 5 elementary school is not only limited to flat buildings. However, it comes to building space as well. Even students must also have knowledge in solving problems related to geometry, flat, and building space. As well as skillfully making his net from building 3-dimensional space. In addition, students must understand concepts related to geometry so as to be able to solve problems related to geometry. Actually, problem-solving in mathematics learning is familiar to students. Problem-solving is closely related to learning both in mathematics and other subjects. Training students to be familiar with problem-solving is very necessary, thus students will be accustomed to understanding the purpose of the problem at hand and thinking carefully in making decisions to solve problems in everyday life. In addition, the importance of spatial ability as a provision in solving geometry problems because it is not uncommon for solving geometry problems involving spatial ability to enter as one of the national examination questions in elementary schools. The difficulties experienced by students in solving geometry problems certainly vary based on the ability of each student. Students' spatial abilities also greatly affect students' performance or achievement in math tasks. The relationship between spatial ability and geometry problem solving is that when students have high spatial skills, it will make it easier for students to understand problems and make decisions to choose the right solving strategy because students are able to imagine in the mind the geometric shape of an object in the problem-solving problem.

BIBLIOGRAPHY

Bosnyak, A., & Nagy-Kondor, R. (2008). The Spatial Ability and Spatial Geometrical Knowledge of University Students Majored in Mathematics. *Acta Didactica Universitatis Comenianae*, *8*, 1–25.

Carroll, J. B. (2005). *The three-stratum theory of cognitive abilities.*

Fraenkel, W., & Wallen, N. (n.d.). *Hyun (2012). How to design and evaluate research in education*. New York: McGraw-Hill.

Gagné, R. M., & White, R. T. (1978). Memory structures and learning outcomes. *Review of Educational Research*, *48*(2), 187–222.

Kariadinata, R. (2010). Kemampuan Visualisasi Geometri Spasial Siswa Madrasah Aliyah Negeri (MAN) Kelas X Melalui Software Pembelajaran Mandiri. *Jurnal Edumat*, *1*(2), 1–13.

Kovačević, N. (2017). Spatial Reasoning in Mathematics. *International Scientific Colloquim Mathematics and Children Founded by Margita Pavleković (6; 2017)*.

Lee, C. I. (2016). An appropriate prompts system based on the polya method for mathematical problem-solving. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(3), 893–910.

Loeber, G. H. (2008). *An inquiry into teacher implementation of NCTM Standards in the kindergarten through second grade instructional setting*. Walden University.

Lowrie, T., Logan, T., & Ramful, A. (2016). Spatial Reasoning Influences Students' Performance on Mathematics Tasks. *Mathematics Education Research Group of Australasia*.

Maier, P. H. (1996). Spatial geometry and spatial ability–How to make solid geometry solid. *Selected Papers from the Annual Conference of Didactics of Mathematics*, 63–75.

OECD. (2019). *PISA 2018 assessment and analytical framework*. OECD publishing.

Özdemir, A. S., Yildiz, F., & Yildiz, S. G. (2015). The Effect of Project Based Learning in" Ratio, Proportion and Percentage" Unit on Mathematics Success and Attitude. *European Journal of Science and Mathematics Education*, *3*(1), 1–13.

Pendidikan, K., & Indonesia, K. R. (2016). KBBI daring. *Diakses Dari Https://Kbbi. Kemdikbud. Go. Id/Cari/Index*.

Polya, G. (2004). *How to solve it: A new aspect of mathematical method* (Vol. 85). Princeton university press.

Prakoso, W. D., Putra, M. Y. D., Mentari, A., & Rahman, B. (n.d.). *Peningkatan Kemampuan Spasial Matematis Melalui Pembelajaran Geometri Berbantuan Geogebra*.

Putri, H. E., Rahayu, P., Muqodas, I., & Wahyudy, M. A. (2020). The Effect of Concrete-PictorialAbstract (CPA) Approach on Improving Elementary School Students' Spatial Sense Ability. *Mimbar Sekolah Dasar; Vol 7, No 1 (2020): AprilDO - 10.17509/MimbarSd.V7i1.19585* .

Runtukahu, T., & Kandou, S. (2014). Pembelajaran matematika dasar bagi anak berkesulitan belajar. *Yogyakarta: Ar-Ruzz Media*.

Ryu, H., Chong, Y., & Song, S. (2007). Mathematically Gifted Students' Spatial Visualization Ability of Solid Figures 1. *Proceedings of the 31st Conference of the International Group for PME*, *4*, 137–144.

Sopiany, H. N., & Rahayu, W. (2019). Analisis Miskonsepsi Siswa Ditinjau dari Teori Kontruktivisme Pada Materi Segiempat. *Jurnal Pendidikan Matematika*, *13*(2), 185–200.

Subroto, T., & Si, S. (2012). Kemampuan Spasial (Spatial Ability). *Prosiding Seminar Nasional Pendidikan Matematika*.

Turgut, M., & Yilmaz, S. (2012). Relationships among Preservice Primary Mathematics Teachers' Gender, Academic Success and Spatial Ability. *Online Submission*, *5*(2), 5–20.

Ulfah, M., & Felicia, L. (2019). Pengembangan Pembelajaran Matematika dalam National Council of Teachers of Mathematics (NCTM) Pada Anak. *Equalita: Jurnal Pusat Studi Gender Dan Anak*, *1*(2), 127–143.

Wardhani, S. (2011). Instrumen penilaian hasil belajar matematika SMP: Belajar dari PISA dan TIMSS. *Yogyakarta: P4TK Matematika*.

Wilson, J. W., Fernandez, M. L., & Hadaway, N. (n.d.). *by Research on Problem Solving*. no.

Yildiz, Sevda Goktepe, & Ozdemir, A. S. (2020). The effects of engineering design processes on spatial abilities of middle school students. *International Journal of Technology and Design Education*, *30*(1), 127–148.

Yildiz, Sevda Göktepe, & Özdemir, A. S. (2017). Development of the Spatial Ability Test for Middle School Students. *Acta Didactica Napocensia*, *10*(4), 41–54.