PAPER • OPEN ACCESS

Spatial information processing of seventh grader in solving Geometry problems

To cite this article: S Wulandari *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **243** 012135

IOP Conf. Series: Earth and Environmental Science **243** (2019) 012135 doi:10.1088/1755-1315/243/1/012135

Spatial information processing of seventh grader in solving Geometry problems

S Wulandari [1], C Sa'dijah[2], E B Irawan[2] and I M Sulandra [2]

[1] Post Graduate Program, Universitas Negeri Malang

[2] Universitas Negeri Malang

pmatshintaw@gmail.com

Abstract. Geometry deals with spatial objects and requires skills to cultivate them. Information processing requires cognitive processes such as recognizing, transferring, rotating and communicating with others. Apparently, there are students who have difficulty in processing spatial information that affects the results of geometric achievement. This study aims to explore information about how students process spatial information. The method used is a descriptive exploratory approach with the subject of three seventh graders in junior high school students. Subjects are asked to complete tasks about the triangle and three-dimensional objects. The results of the study indicate that there are obstacles in processing spatial information, namely in the encoding process. The first and second subjects have difficulty in recognizing objects and represents rotated objects. The third subject has difficulty imagining spatial objects without any media modelling them.

1. Introduction

Geometry is a branch of mathematics that studies the object of two-dimensional and three-dimensional objects. The two of dimension objects are interrelated, for example, the concept of nets. A net is a two-dimensional form that can be folded into three-dimensional objects [1]. Studying the nets can help students in making connections between two-dimensional and three- dimensional objects.

In studying the three-dimensional objects there are two- dimensional objects that need to be mastered. A three-dimensional object requires an understanding of two-dimensional concepts [2]. In seventh grade students, the concept of a triangle is given at the end of the second semester. The concept of triangle needs to be mastered to construct concepts such as the concept of a triangular pyramid, triangular prism, and other three dimensional objects. However, there is a student whose spatial ability is lacking, meaning that they do not recognize changes in object position, not knowing the relationships between objects and cannot imagine the objects seen from a particular point of view. The study conducted by Musser and Burger [2] emphasized that spatial ability is needed in studying three-dimensional and two-dimensional objects.

Spatial ability is the ability of a person to visualize an image or create it in the form of two or three-dimensional object [3, 4]. Someone who has high spatial ability tends to learn easily through visual images. Good spatial skills will enable students to detect the relation between spatial object and transform it when learning geometry. Understanding the relationship and the nature of spatial objects in geometry is needed in solving mathematical problems and problems in everyday life [5, 6, 7, 8].

Spatial ability consists of three components: spatial visualization, spatial relations and spatial orientation [9, 10]. Spatial visualization is the ability to mentally manipulate the movement of a spatial object. Spatial orientation is the ability to imagine a spatial object from a particular point of view. The spatial relationship is the ability to make connections between spatial objects. These three components are needed when someone processes spatial information.

Spatial information processing occurs cognitively. Verbal and graphic representations are needed to explore individual cognitive schemes [11]. In this research, information processing is presented using a cognitive scheme in the form of a flowchart [12]. Informaion processing theory is a cognitive learning theory that is related to the way individuals encode, store and retrieval knowledge from the mind [11]. Encoding is the process of changing information from the real world so that it can be stored in the memory; storage is a process that has been retaining encoded information so that it is stored in memory and retrieval is the process of retrieving or remembering what has been stored in memory [11].

Spatial ability is related to cognitive processes for processing spatial information. Cognitive processes that occur include moving, transforming, editing and representing spatial objects so that they can be communicated with others [3]. Information processing theory underlies how information can be stored to be recalled when needed. For this reason, it is necessary to explore how information processing for spatial objects and what spatial abilities are needed when completing geometry tasks. The purpose of this study is to explore the information processing of student based on information processing theory. In particular, this study produces information processing schemes and spatial ability activities in solving geometric problems.

2. Research Method

2.1. Subject
The subject of this study consisted of three seventh grade students at SMPN 1 Ngantang, Kabupaten Malang. The three subjects are chosen based on their high spatial abilities and good communication skills. The subject's spatial ability is seen from the spatial ability test and communication skills based on the mathematics teacher's recommendations. Subjects solved geometry task about 45 minutes, then followed by an in-depth interview.

2.2. Instrument
The instruments in this study consisted of two types, geometry tasks and interviews. Geometry tasks can determine activity related to spatial ability. It consists of two parts. First, about congruence in the two triangles and the second about the nets that can form cubes. In the first part, each subject was asked to determine his opinion about the truth of the statement and was asked to write down the reason. In the second part, the subject is asked to write the results of the task. After completing the geometry task, each subject was interviewed. In-depth interviews were conducted to gather information about how to process spatial information on each subject.

2.3. Data analysis
This research is a qualitative research with descriptive exploratory approach [13, 14]. The data obtained were analyzed using steps: 1) encoding to capture events related to spatial information processing and spatial activities, 2) data reduction to sort the required data, focus the data as needed, 3) description to answer the research problem: in this step, data is presented in the form of a flowchart which is a spatial information processing scheme and 4) conclusion.

3. Result and Discussion
Subjects in this study used the names P1, P2 and P3. The three subjects completed two tasks and then were interviewed to get information about how the spatial information processing is. Results of subject work appear in the following table.

Table 1. The subject answer to geometry task.

Subject	Answer	
	Task 1	Task 2
P1	F	T
P2	F	T
P3	T	T

F: false answer
T: true answer
Table 1 illustrates that all subjects can complete task 2 correctly. According to Jeon [1], the task of arranging the square that forms the cube net is one component that can measure one's spatial ability. Based on table 1, two subjects had an error in solving it. Task 1 is designed to process spatial information that is spatial orientation. Thus the three subjects have good spatial abilities. Spatial information processing is described in the following subsections.

3.1. The processing of spatial information on P1
The processing of spatial information of subject P1 on first task is illustrated by the following scheme. Figure 1 show a spatial information processing scheme. Spatial information begins with the encoding process, for example, P1 recognizes the existence of two triangles on the problem [11]. It is continued by extracting information on object by measuring the length of each side of the triangle. The triangular information along with its size is then stored in memory by P1. In this process, P1 does not encode in the position of two triangles, so P1 does not realize that the two triangles are actually two triangles whose position is rotated clockwise by 45^0.

Note :
En = encoding
St = storage
Rt = retrieval

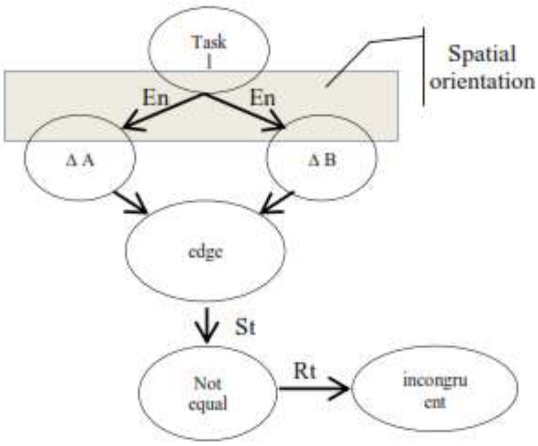


Figure 1. Spatial information processing scheme P1 on task 1.

Here are the results of interviews on P1 related to the position of two triangles A and B.
Obs: Two triangles are not congruent. Why?
P1: That's because the size is not the same
Obs: Which part?
P1: This side with this side is not the same (while pointing to the side of the intended triangle)

Based on the interview, P1 considers that the two sides of the triangle are not the same. Subject P1 points to the side of the triangle which is the two incompatible sides. According to Musser & Burger [2], two congruent triangles corresponding sides and angles have the same size. Based on the concept of the triangle it has, P1 concludes that the two triangles are not congruent. The inaccurate inference of the information obtained is due to P1 having no ability in spatial orientation so as not to realize that the two triangles are congruent.

Note :
En : encoding
St : storage
Rt : retrieval

Im 1: imagine the movement of a square that is folded so as to form a cube
PAT: determine the position of the base of the cube if the lid is known

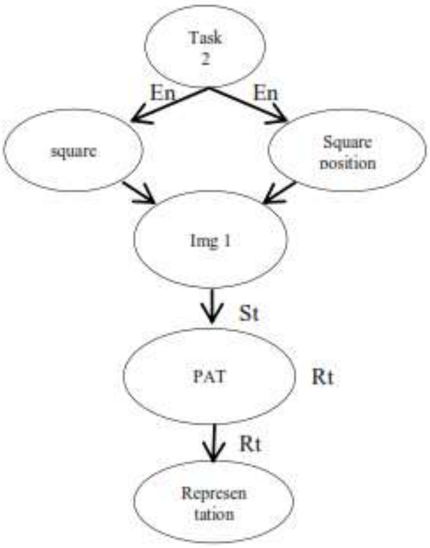


Figure 2. Spatial information processing scheme P1 on task 2.

The second task is completed by P1 correctly. Figure 2 shows that P1 processes spatial information from encoding, storage to retrieval properly. Based on Figure 2, P1 uses an imagistic approach to determine the square as the base of the cube. This means that in spatial information processing, P1 performs encoding, imaging and representing steps [4]

3.2. The processing of spatial information on P2
The first task completed by P2 appears in Figure 3 below. Based on figure 3, P2 completes the task of determining the congruence of two triangles through encoding, storage, and retrieval processes. In spatial information processing, P2 performs triangle encoding by measuring the side length on the test sheet.

Note :
En = encoding
St = storage
Rt = retrieval
PsA = length of edge on A
PsB = length of edge on B

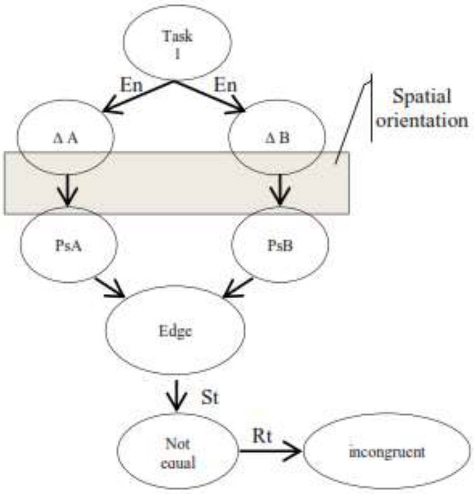


Figure 3. Spatial information processing scheme P2 on task 1.

By sketching the length of sides, P2 compares two triangles to conclude whether the two triangles are congruent or not. However, when encoding, P2 does not use its spatial orientation abilities.
Similar to P1, P2 does not realize that two triangles are equals, because one is triangular of other

IOP Conf. Series: Earth and Environmental Science **243** (2019) 012135 doi:10.1088/1755-1315/243/1/012135

triangular turns. In the interview, P2 gave the reason that the two triangles in the second task were not congruent. According to P2, not congruent means not the same. Here are the results of interviews with P2 related task 1.

Obs : You said that these triangle are not congruent. Why?
P2 : mmm, because it is not congruent
Obs : what does it mean?
P2 : the shape is not the same, it should be a triangle. If A isolesence than B also isolesence too.

In first task, the subject cannot complete the task correctly because he does not use spatial orientation skills and does not master the concept of congruence of two triangles.

Note :
En : encoding
St : storage
Rt : retrieval
Mod: create a paper model that fits the cube nets on task2
PAT: determine the position of the base of the cube if the lid is known

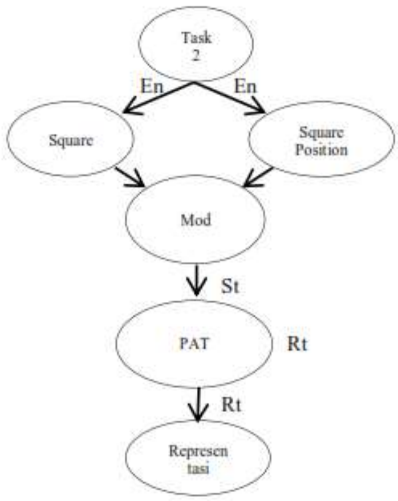
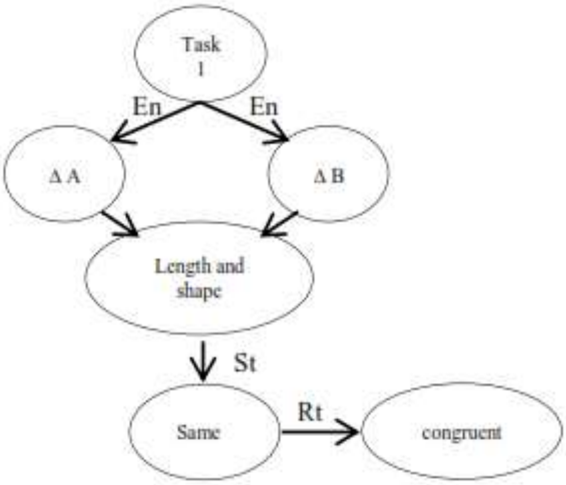


Figure 4. Spatial information processing scheme P2 on task 2.

The second task is done well by P2. Different from P1, P2 uses cropped paper resembling cube nets on the problem to make it easy to determine which base of the cube. Subject P2 says that using a paper-cut model is easier to determine the base of the cube in question. This is in accordance with a study by Cohen & Hegarty [16] that in solving spatial problems, subject whose using models their performance are better than those not using them.

3.3. The processing of spatial information on P3

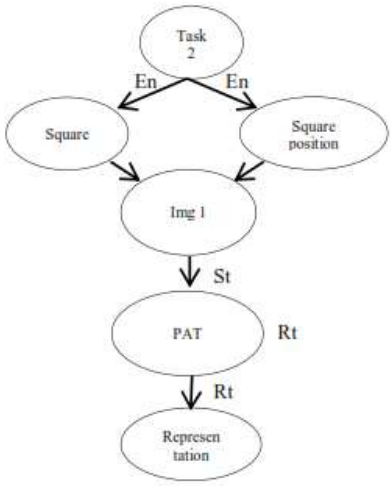
The P3 subject completes the assigned task correctly on the first task as well as on the second task. Based on figure 5, the first task begins by encoding a triangle by measuring the length of the three sides of each triangle by using a ruler. With this encoding, P3 stores information that the triangle has the same side length on the corresponding sides. Then P3 compares the two triangles and the result is to have the same shape and size. At the end of information processing, P3 recalls the information of triangles A and B, the size of each side of the two triangles and the results of the comparison of two triangles. Based on this information, it was concluded that the two triangles were congruent.



Note :
En = encoding
St = storage
Rt = retrieval

Figure 5. Spatial information processing scheme P3 on task 1.

Based on figure 6, it can be seen that P3 starts the completion of the task by encoding the square shape arranged as a net cube. Figure 6 illustrates that the processing of spatial information begins with encoding, storage, and retrieval. The encoding process is done by P3 by recognizing the position of the square and the number of squares.



Note :
En : encoding
St : storage
Rt : retrieval
Im 1: imagine the movement of a square that is folded so as to form a cube
PAT: determine the position of the base of the cube if the lid is known

Figure 6. Spatial information processing scheme P3 on task 2.

The square position includes recognizing the square position as a cube cap. Furthermore, P3 stores the spatial information in the form of cube nets as well as the square position as a cube cap. Subject of P3 then proceeds to mentally imagine the movement of a square to form a cube. The retrieval process occurs when P3 concludes that the base in question is the square marked on the answer sheet in the form of a drawing sketch.

3.4. Discussion
Based on the results of the study, it was found that in resolving tasks geometry required spatial information processing. The information obtained on spatial objects is processed in such a way that it can be stored in memory and at one time can be remembered and recalled to resolve a spatial problem. Spatial information processing in this study begins with encoding then storage and ending with retrieval. At the encoding stage, extracting information on spatial objects is needed. In accordance

with the given task, encoding is done when the subject is dealing with spatial objects. According to Sternberg [9], encoding is needed before information is stored in memory, either short-term memory or long-term memory.

The storage process on spatial objects requires a way to make the encoded information stronger stored in memory. According to Sternberg [9], the storage process requires good settings to be stored properly in memory. In this study, the storage process appears when grouping objects according to their characteristics, which are based on objects of the same size and shape.

In this study, two subjects encountered obstacles to the process of spatial information processing. Obstacles appear when determining two congruent triangles. Although both are congruent, different positions can affect information processing. Both subjects decided that two triangles that should be congruent were not congruent because of the position viewed from a different angle. They do not realize that one of the triangles is rotated around 45^0 clockwise. The other subject decided that the two triangles were congruent, he reasoned that the two triangles had the same shape and size. Weaknesses in the concept of triangles are also conveyed by Koyunkaya [13]. This weakness is caused by the weak spatial ability that is when the subject is dealing with the problem of objects viewed from different angle [16].

Spatial ability namely visualization and spatial orientation is needed in completing geometry tasks. Spatial orientation is needed on objects that are presented at different points of view, so that spatial objects can be identified. Spatial relations are more widely used in the retrieval process that is when the subject performs the activity of recalling the stored object such as a triangular object with a side that has a certain size, six square arranged in such a way as the shaded square as a cube cover. Through this study, it is known that spatial ability is needed to extract information accurately. Spatial ability is needed in the encoding process. The finding of this study is that the subject modelled cube nets from paper to facilitate spatial visualization. The use of real object models can improve students' mathematical abilities [2, 17].

4. Conclusion

Spatial information is an important thing needed in studying the object of the two-dimensional and three-dimensional object. Spatial information supports a person to recognize the position of an object either encountered directly or during a process of remembering an object. Subjects process spatial information properly and accurately using their spatial abilities. In this research, the processing of spatial information consists of encoding, storage and retrieval. Visualization and spatial relations are used by the subject but not in spatial orientation. Spatial information processing runs well if students have good spatial ability. The encoding process in this study requires ability in visualization and spatial orientation. The encoded information will be stored in memory through the storage process. Well stored information can be recalled when needed. Recalling information requires ability in spatial relations. Knowing the processing of spatial information can be used as a consideration for teachers to develop appropriate learning strategies so that learning objectives can be achieved.

Acknowledgement

Thank you to the Headmaster of SMPN 1 Ngantang Kabupaten Malang for his permission to collect the data.

References

[1] Jeon K 2009 *Teaching Children Mathematics* (NCTM Inc) p 394 – 399

[2] Musser G L, Burger W F and Peterson B E 2011 *Mathematics for Elementary Teachers a Contemporary Approach Ninth Eds* (John Wiley and Sons Inc.) p 575-660

[3] Gecu Z and Erkoc M F 2015 Effects Of Computer Game Experiences on Children's Spatial Abilities *Intr. J. Socials Science and Education* **5** p 580 – 589

[4] Hegarty M and Waller M 2004 A Dissociation Between Mental Rotation And

IOP Conf. Series: Earth and Environmental Science **243** (2019) 012135 doi:10.1088/1755-1315/243/1/012135

Perspective-Taking Spatial Abilities *J. Intelligence* **32** p 175 – 191

[5] Wai J, Lubinski D and Benbow C P 2009 Aligning Over 50 Years of Cumulative Psychological Knowledge Solidifies Its Importanc *J. of Educational Psychology* **101** p 817-835

[6] Wakabayashi Y and Ishikawa T 2011 Spatial Thinking in Geographic Information Science: A Review of Past Studies and Prospects for the Future *J. Procedia Social and Behavioral Science* **21** p 304-313

[7] Yilmaz B 2009 On the development and measurement of spatial ability *Intr. Electronic J. of Elementary Education* **1 (2)** p 83-94

[8] Amrina Z, Desfitri R, Zuzano F, Wahyuni Y, Hidayat H and Alfino J 2018 Developing Instruments to Measure Students' Logical, Critical, and Creative Thinking Competences for Bung Hatta University Students *International Journal of Engineering & Technology* **7 (4. 9)** p 128 – 131

[9] Sternberg R J and Sternberg K 2012 *Cognitive Psycology* (Wadsworth) p 260-300

[10] Subanji *Teori Kesalahan Konstruksi Konsep dan Pemecahan Masalah Matematika,* (Universitas Negeri Malang) p 53-104

[11] Fraenkel J R, Wallen N E and Hyun H H, *How to Design and Evaluate Research in Education*, McGraw-Hill p 435–437

[12] Cresswell J W 2005 *Educational Research* (Pearson Education Inc.) p 7 – 11

[13] Koyunkaya M Y 2017 An Examination of a Pre-service Mathematics Teacher's Mental Constructions of Relationships in a Right Triangle *Intr. J. of Mathematics Education in Science and Technology* **47 (7)** p 1028-1047

[14] Mix K S, Levine S C, Cheng Y L, Young C, Hambrick D Z and Ping R 2016 Separate But Correlated: The Latent Structure of Space and Mathematics Across Development *J. of Experimental Psychology: General* **145 (9)** p 1206 – 1227

[15] Cohen C A and Hegarty M 2012 Visualizing cross sections: Training spatial thinking using interactive animations and virtual objects *J. Learning and Individual Difference* **22** p 868-874

[16] Hawes Z, Moss J, Caswell B and Poliszczuk D 2015 Effects of Mental Rotation Training On Children's Spatial And Mathematics Performance: A Randomized Controlled Study *Trends in Neuroscience and Education*

[17] Lady A, Tri B U and Chikita L 2018 Improving mathematical ability and student learning outcomes through realistic mathematic education (RME) approach *International Journal of Engineering & Technology* **7 (9. 12)** p 55 – 57