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The Spatial Visual Reproduction Of Vocational High School Students To Construct Cube

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Abstract

Reproduction visual-spatial students with regard to the pattern of spatial reasoning. Spatial reasoning is non-verbal information processing in the form of images to resolve the issue. Related to the above, this study aims to describe the flow of spatial reasoning students in constructing the cube. This study uses a qualitative descriptive design research subjects which are involving 8 Vocational High School students of class XI Technical expertise Building Pictures selected using purposive sampling technique as participants. Beside the researchers are as the main instrument in collecting data, it is also used a supporting instrument in the form of duties. Data analysis is performing method of constant comparison analysis. The results of analysis from this study leads to four conclusions. First, the Sharpening Emphasizing (SE) spatial reasoning, the Sharpening Structurally Conditioned Change (SSCC) spatial reasoning, the SE-SSCC spatial reasoning, and the Double SSCC spatial reasoning.

Keywords: constructing, cube, reproduction, visual-spatial, rotation, fixed point.

Mathematics is a compulsory subject that is given to vocational students. The duration of time spent in the learning of mathematics in vocational longer than other subjects, namely between 330-516 hours of lessons in three years (Minister of National Education of the Republic of Indonesia, 2006). One of vocational subjects in the

Department of Drawings and Building is drawing projections. In drawing projections, students learn ways to draw an object from various angles, such as images of objects when viewed from the right front will look different when viewed from the front left. So that at the time of drawing the projection, the student must be able to imagine the position of an object when viewed from different angles. Skills imagine objects from various different viewpoints play an important role in the study of the students, as it relates to the work to be done in real life. Skills imagine objects from various different viewpoints is the largest component of spatial ability (Hegarty & Waller, 1999).

Spatial ability is a cognitive skill in representing, transform, build, and call back the symbolic information not in the form of language but in the form of images (Black, 2005). Olkun (2003) suggests that there are two main components of spatial ability which spatial relationships and spatial visualization. Spatial relation defines as shadow rotation of objects in two dimensions and three dimensions. While spatial visualization defines as shadow rotation of the object and its parts in three dimensional space.

Spatial ability correlates strongly with student success in Science, Technology, Engineering, and Mathematics (STEM) (Newcombe, 2010; Wai, Lubinski, & Benbow, 2009; Turgut & Yilmaz, 2012; Basham & Kotrlik, 2008). Spatial ability of students can be developed not only through the projection drawing lessons but also of other subject matter, for example, of the material geometry of space. Spatial ability students greatly affect student success in learning the material geometry of the space (Idris, 2005; Jones, 2001). This is supported by Gunhan, Turgut, & Yilmaz (2009) which states that the geometry is closely related to spatial ability (spatial ability).

Geometry is closely related to the objects that exist in the environment, so as to learn the student must know the object or minimally able to visualize the object. Not all students have the same ability to visualize an object (Rafi, Samsudin, & Said, 2008; Sorby, 1999; Peters, Chisholm, & Laeng, 1994; Toptas, Serkan, & Tugce, 2012). This resulted in some students have difficulty in understanding the concepts of geometry, which in turn will hamper the process of learning material subsequent geometry.

Difficulty in understanding the concept of geometry students, among others, is shown in the results of research Gonzales, et al., (2009, p. 12). In that study, the material tested for eighth grade students there are four, namely: numbers, algebra, geometry, and data analysis. From the results of four such material, it turns out the average scores on the geometry of the material is the lowest. According to Okamoto (2014), the low scores obtained on the geometry of the material shows the difficulty of students in spatial thinking.

In Learning To Think spatially (2006, p. 12) stated that:

> "Spatial thinking, one form of thinking, is a collection of cognitive skills. The skills Consist of declarative and perceptual forms of knowledge and some cognitive operations that can be used to transform, combine, or otherwise, operate on this knowledge. The key to spatial thinking is a constructive amalgam of three elements: concepts of space, tools of representation, and reasoning processes ".

Spatial concepts are used among others as a basis for determining the dimensions (two-dimensional or three-dimensional). Tool is a representation of an image to explain something, for example, describes the effects projection, connecting multiple perspectives (eg. in the manufacture of the building, which connects the building height perspective on the image of planning with the actual height of the building or vice versa). While the reasoning is a way of thinking to explain something, such a way of thinking in determining the implementation of the rotation when constructing geometry.

Reasoning that use spatial representation (such as charts, graphs, and gesture) for reason called spatial reasoning (Gattis, 2004). Moreover, according to Bruning, Schraw, & Ronning, (1995, p. 55) is a spatial reasoning process nonverbal information provided by the premises (statement of the various concepts that can be used as an ingredient to explain the conclusions) on the issue of conclusion. While Bloch (2006) defines spatial reasoning as the domain of spatial knowledge representation consisting of spatial knowledge representation and reasoning. Spatial reasoning abilities of each individual thrived on the age of the children (Verdine, et al., 2013 in Moss, et al). In children aged 5 years and 6 months to 5 years and 11 months of spatial reasoning ability has increased very rapidly. Whereas in children ages 7 years to 7 years and 5 months has increased very rapidly is quantitative reasoning ability (Tian & Huang, 2009). Spatial reasoning skills can be developed through the use of various results of technological advances, among others, using the iPad (Bruce, 2014), using Sketchpad (Oi-Lam, 2014), and the design of the robot (Francis, 2014).

Spatial reasoning abilities of children can be known from a variety of factors, one of the ways of determining the angle of view (Panhuizen, Elijah, & Robitzach, 2014). According Flavel (in Moll & Meltzoff, 2011), children's ability to see an object from a particular viewpoint divided into two levels. The first level: the ability to deduce where the object and not the object of a particular viewpoint. The second level: the ability to make judgments about how an object seen from a certain perspective. Panhuizen, et al. conduct research on the determination of the viewpoint based pelevelan conducted by Flavel. In his research, Panhuizen, et al. (2014), among others, looked at the relationship between determination of viewpoints to the cultural background, as well as the relationship between the determination of the gender

viewpoint. Referring to the results of research Panhuizen et al. mentioned above, this study focuses on the observation of students' ability to construct models of the cube from a certain perspective. This is done to analyze the spatial reasoning of students in constructing a model of the cube. To obtain preliminary information about spatial reasoning student in constructing the model cube above then conducted a preliminary study in one of the SMK in Malang, East Java Indonesia.

In the preliminary study, the observed behavior and facial expressions that indicated students when learning to draw projections. By the time the teacher explains the tasks to be completed for the day, all the students were seriously listen to the teacher's explanations. As for the students' work to be done that day is drawing a cupboard on the right side there is a calendar. After hearing the testimony provided by the teacher, the students gave a mixed response to different reasons. There are students who live drawing, there is a sketch first, and there are also students who look silent (as brooding) by occasionally moving his hand (like drawing in air).

At other times, this study looked at the behavior and facial expressions that indicated the student when the teacher gives some questions relating to the nets and wake shape space. When given various forms of webs as in Figure 1, and the students were asked "which of these nets are nets cube and not the nets of the cube?" Students can quickly determine which is the nets of the cube is (a , b, f, and h) and the non nets cube is (b, c, d, e, g, and i).

Similarly, when students are asked to determine the shape of a cube nets that have images on three sides as in Figure 2, students can quickly determine which is the nets of the cube is an image B.

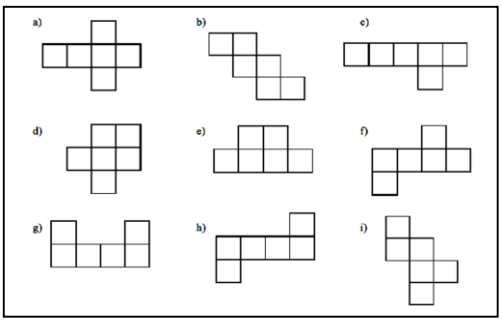


Figure 1. Figure various forms of nets cube

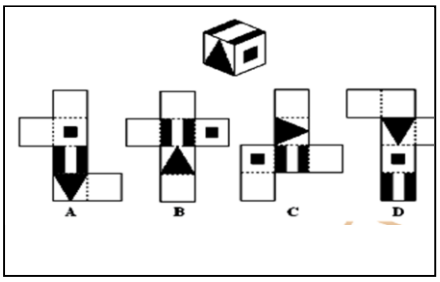


Figure 2. Figure cubes and various forms of nets

But when students were asked to construct a model of a cube nets have three pictures on its surface, the students turned out to have a variety of answers to different reasons. As for the answer to a few students, among others, as in Figure 3 as follows:

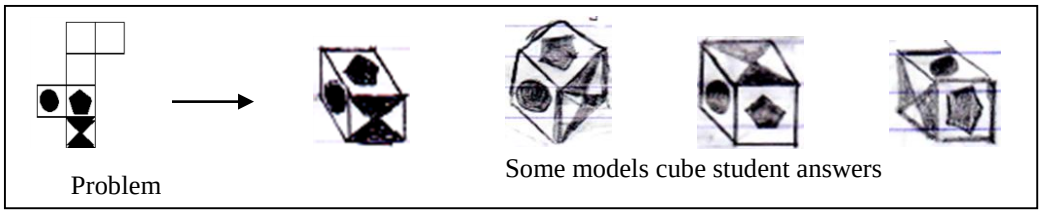


Figure 3. Figure cube models student answers

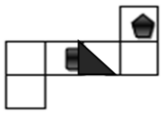
Of the various answers given student, found indications of this line of reasoning spatially different from these students when constructing the model cube. Based on the description that has been presented about the importance of spatial reasoning in mathematics, then conducted a study that focused on how the flow of spatial reasoning students Vocational High School (SMK) in constructing the model cube. So the purpose of this study was to describe the flow of spatial reasoning vocational students in constructing the model cube.

METHODS

This research is qualitative descriptive case study design. Subjects were selected from a class XI of Department of Architecture Engineering (TGB) in the Vocational School (SMKN) 6 Malang because the majors TGB students are required to have higher spatial abilities than other students majors. Research subjects have been as many as 8 people with purposive sampling technique. Criteria selected students as subjects are students: a) Has the pattern of spatial reasoning according to categories that have been determined based on the rotational position in the structure reasoning namely: the SE category (without rotation), SSCC category (starting rotation), SE-SSCC category (ending rotation), and double SSCC categories (begins and ends rotation). b) Can communicate well, c) Willing to be a subject of research. Each category is represented by two students because of the two subjects of this study, the groove reason students are revealed.

Determination of four categories based on the pattern of spatial reasoning preliminary study, in which researchers asked 10 students majoring TGB to construct a picture of the model nets three sides of the cube that has a sign (image). Task completion results of the student in the selection phase of the study subjects showed that of the four categories of research subjects (without rotation, starting rotation, ending rotation, and the rotation begins and ends), there are some subjects who made a mistake on the

settlement question number 3. Therefore, Question 3 researchers selected as the instrument used to collect data at the interview stage with the following picture:



RESULTS AND DISCUSSION

The process of spatial reasoning to students, in general, can be explained by activities that emphasize Sharpening, Sharpening Normalizing, Sharpening Structured Conditioned Change and Normaling Leveling. As each subject category of research will go through some or all of the above-mentioned activities in the spatial reasoning process, the results of the analysis presented in this article will be represented by the SE category and the Double SSCC category.

Spatial Reasoning Subject SE Category

Students who become the subject of research in the SE category is S1 and S2. When completing the task the first category, S1 and S2 immediately construct models of the cube after observing and understanding the drawing nets given (input). In the first category of task completion, S1 and S2 directly focused on the model construction cube with three sides that signed simultaneously visible from the front (output). S1 and S2 initiated a process reasoning with emphasizing sharpening process that is the subject imagine determine a fixed point, the direction of folding, and the sides of the cube were constructed first. Furthermore, S1 and S2 perform sharpening process of normalizing cube that draws in the direction of a certain angle. Last S1 and S2 perform leveling normalizing process, namely a sign on all three sides of the cube so that the three sides of the cube signed simultaneously visible from the front.

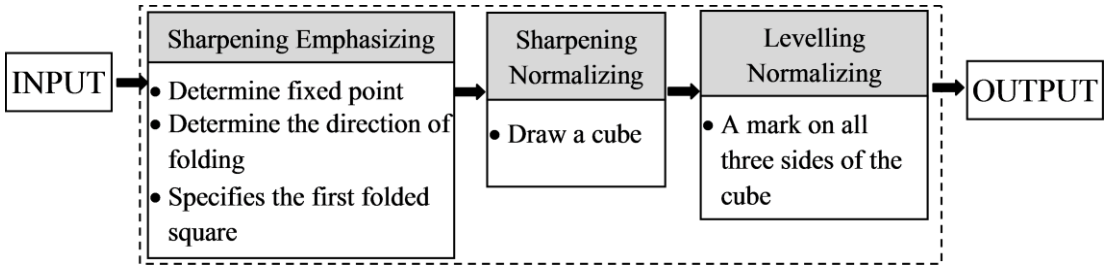


Figure 4. Flow reasoned SE category subject to the completion of the task of the first category

Based on Figure 4 above, it appears that the SE subject category only makes the sharpening process emphasized, sharpening normalization, normalization and generalization in the reasoning process while building the cube model. This means that the subject category SE does not make the process of sharpening the structural conditions change in the process of reasoning. Because the process of sharpening the condition of structural change is not done, then the subject category SE does not apply the principle of rotation in the cube construction process. Therefore, it can be concluded that the SE category stream of spatial tuning that is subject to the completion of the task of the first category is "no rotation".

While in the second category of task completion (equal to the task input and output of the first category of the model cube with a sign on the front side is determined), S1 and S2 initially focused on constructing models of the cube as the completion of the task of the first category. The S1 and S2 reasoning process when constructing models of the cube in the first category is the task begins sharpening process that is the subject emphasizing imagine determine a fixed point, the direction of folding, and the first models constructed cube. Furthermore, S1 and S2 perform sharpening process of normalizing cube that draws in the direction of a certain angle. Last S1 and S2 perform normalizing leveling process is signaled to the third side of the cube, so that all three sides of the cube signed simultaneously visible from the front. Once formed a cube, S1 and S2 are now focusing on the adjustment of the position of the sign on the front side of the cube with command matter. S1 and S2 imagine the rotation of the cube of the new construction, to adjust the position of the sign on the front side of the cube with command matter. The reason groove S1 and S2 (subject category SE) on completion of the task the second category can be described as follows:

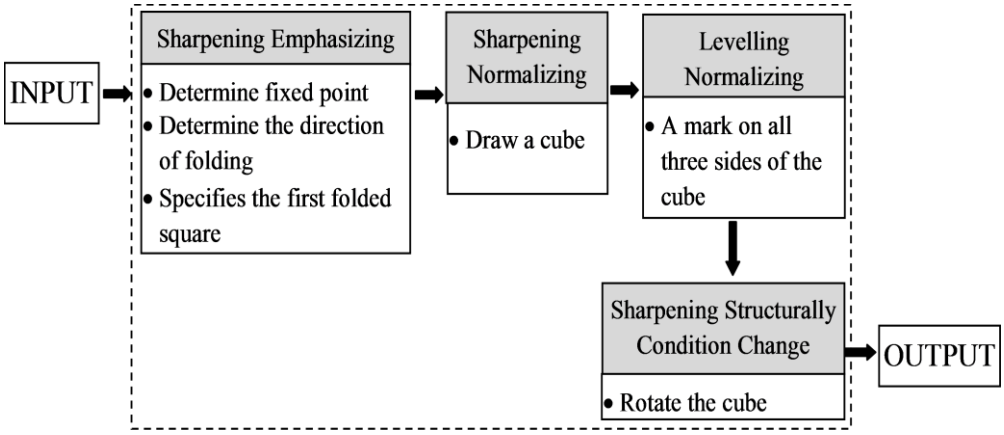


Figure 5. Flow reasoned SE category subject to the completion of the task of the second category

Based on Figure 5 above, it appears that the subject category SE sharpening process emphasizing, sharpening normalizing, normalizing leveling and sharpening structurally condition reasoning change in the process. Sharpening condition structurally changes process made subject category reasoning SE at the end of the process. This means that the subject category SE applies the principle of rotation at the end of the process construction the cube. Therefore, it can be concluded that the flow of spatial reasoning SE category subject to the completion of the task of the second category is the "end of a rotation."

Spatial Reasoning Subject Doubel SSCC Category

Students who become the subject of research categories is double SSCC S7 and S8. When complete the task the first category, S7 and S8 directly to rotation of the image nets, after observing and understanding the drawing nets given (input). Cube are constructed S7 and S8 at the beginning of the settlement, in the form of the cube with one side signed not visible from the front. S7 and S8 do a rotation about the cube so that three sides of the cube signed simultaneously visible from the front (output). S7 and S8 reasoning process started with the process of sharpening structurally condition change is doing to the image rotation nets. After that S7 and S8 emphasizing sharpening process that is the subject of determining the fixed point, imagine the direction of folding drawing nets, and specify the cube are constructed first. The next S7 and S8 normalizing sharpening process that is the subject of a direction to draw the model cube particular viewpoint. Then, S7 and S8 normalizing leveling process that signs the third position signs on the sides of the cube of the new construction.

Furthermore, S7 and S8 sharpening process condition structurally change the subject imagine that rotation of the cube of the new construction. S7 and S8 final construct cube and sign the third position signs on the sides of the cube that have undergone the rotation so that the three sides of the cube signed simultaneously visible from the front. The reason groove S7 and S8 (subject category Double SSCC) on completion of the task of the first category are presented in Figure 6.

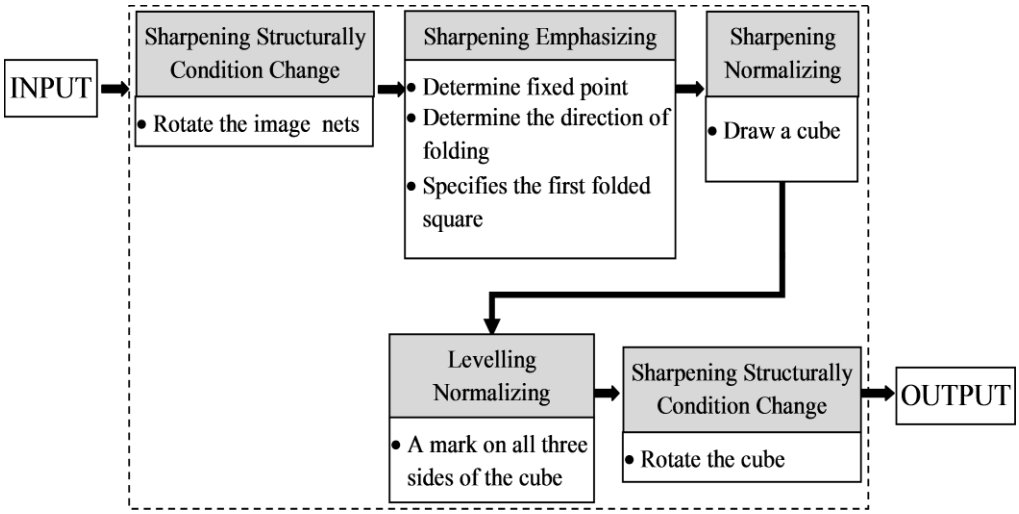


Figure 6: Flow reasoned Double SSCC subject category on completion of the task first category

Based on Figure 6, it appears that the subject category Doble SSCC sharpening process emphasizing, sharpening normalizing, normalizing leveling and sharpening structurally condition reasoning change in the process. Subject category Double SSCC sharpening process condition structurally change at the beginning and end of the process reasoning. This means that the subject category Double SSCC apply the principle of rotation at the beginning and end of the process construction the cube. Therefore, it can be concluded that the groove reasoned Double SSCC subject category on completion of the task the first category is "begins and ends rotation."

While in the second category of task completion, S7 and S8 is initially focused on the direction of the adjustment in the picture nets with the direction of the front side of the cube in order matter. To adjust the position and direction of the image, S7, and S8, the rotation of the image nets, in this case, the subject of sharpening process condition structurally change. After that S7 and S8 emphasizing sharpening process that is the subject of determining the fixed point, imagine the direction of folding drawing nets, and specify the cube are constructed first. The next S7 and S8 normalizing sharpening process that is the subject of drawing models folding picture cube results nets that have been imagined. Then the subject of normalizing leveling process which signs the third position signs on the sides of the cube of the new construction, so three sides of the cube signed simultaneously visible from the front. The reason groove S7 and S8 (subject category Double SSCC) on completion of the task the second category can be described as follows:

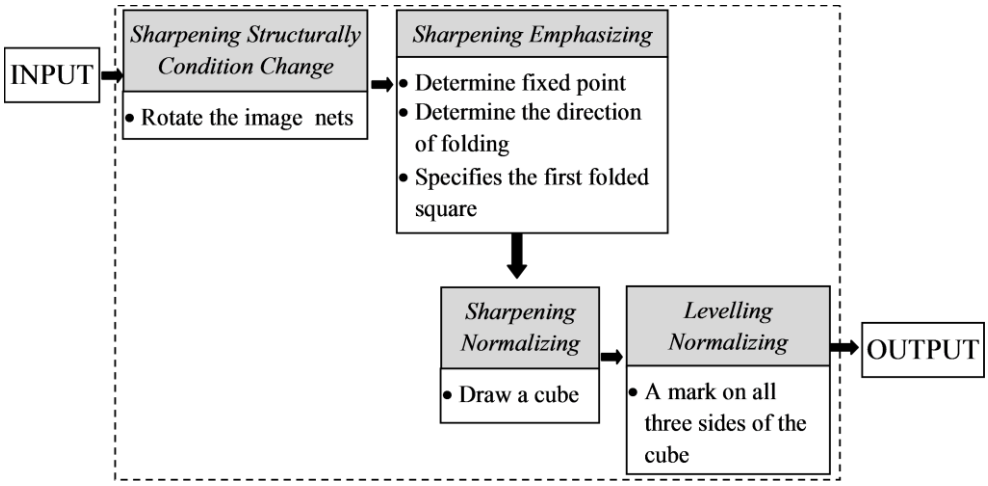


Figure 7: Flow reasoned Double SSCC subject category on completion of the task second category

Based on Figure 7 above, it appears that the subject category Doble SSCC sharpening process emphasizing, sharpening normalizing, normalizing leveling and sharpening structurally condition reasoning change in the process. Subject category Double SSCC sharpening process condition structurally change at the beginning of the process reasoning. This means that the subject category Doble SSCC applies the principle of rotation at the beginning of the process construction the cube. Therefore, it can be concluded that the groove reasoned Double SSCC subject category on completion of the task the second category is "starting rotation".

Findings "Interesting" Relating With Spatial Reasoning

Lithner (2012) states that the reasoning could be viewed as a process of thinking, as a product of the thinking process, or as both. Referring to the opinion of Lithner, the findings of this study will be reviewed as a thought process and as a product of the thinking process. Spatial reasoning is seen as a process of thinking will be assessed based framework Berqvist (2008). In the frame of mind mentioned that the thinking process is divided into two categories namely the process of creative thinking and the process of artificial thinking. While viewed as spatial reasoning products though the process will be assessed based on the framework of Subanji & Supratman, A.M (2015). Within the framework of Subanji & Supratman mentioned that reasoning divided into three categories, namely reasoning is correct, pseudo reasoning, and reasoning is wrong. Because researchers only observing and photographing the process of reasoning from a subject who successfully complete the task correctly, then the wrong reasoning is not found in this study.

Spatial reasoning in this study divided into four categories: Category SE, category SSCC, SE-SSCC category, and the category Double SSCC. Of the four categories,

spatial reasoning SE category is the simplest category. Based on these four categories, the findings in this study will be elaborated by a group of research subjects are subject category SE, subject SSCC, SE-SSCC subject category and subject category Double SSCC. But in this paper only invention at subject category SE and category Doubel SSCC to be elaborated.

Findings On Spatial Reasoning SE

Students who become the subject of spatial reasoning SE is S1 and S2. On completion of the task of the first category (construct models of the cube with a sign on the front side model of the cube is not specified), S1 and S2 begin the process of determining to reason the square is used as fixed side. S1 determines the front side model of the cube as a fixed side. After that S1 imagine determine the direction of the folding picture nets, ie towards the outside. While S2 determines the lower side of the cube as side continues to determine the direction of the folding picture imagine nets, namely inward. At the time of folding picture imagine doing sets, S1 and S2 less attention to the occurrence of a change of direction in the figure signs the nets so that there is an error in the first settlement. But at the completion of both S1 and S2 successfully construct cube perfectly without making mistakes.

Whereas when constructing the model cube with a sign on the front side of the cube defined, S1 and S2 change the structured reasoning. S1 reasoning starts the process by determining the square is used as the back side of the cube as a model of fixed side. While S2 determines the lower side of the cube as a model of fixed side. Furthermore, S1 and S2 imagine determining the direction of the folding picture nets, namely inward. After drawing the cube, S1 and S2 imagine the rotation of the cube of the new construction. S1 and S2 imagine doing a rotation to adjust the direction and position of the sign on the front side of the new cube construction with command matter.

When viewed from the framework Subanji & Supratman, A.M (2015) spatial reasoning S1 and S2 in completing the task of the first category is a pseudo reasoning. Namely, the reasoning process that produces the wrong answer, but after some reflection, the subject is able to fix the error in the solution so that a correct answer. Meanwhile, if the review of the framework Bergqvist, et al. (2008), the process of reasoning S1 and S2 is a process of creative thinking. In the second settlement, S1 and S2 are able to make back the forgotten sequence, which resulted in the completion of the first incorrect answer. In addition, S1 and S2 are able to make new steps in solving the second category. This means that they do adaptations and different approaches to solve different problems. Of each strategy on the solution, S1 and S2 is able to convey the reasons that explain why the settlement is considered right or make sense of mathematics.

Findings On Spatial Reasoning Doubel SSCC

Students who become the subject of spatial reasoning double SSCC is S7 and S8. When constructing a model of the cube with a sign on the front side of the cube is not specified models, S7 and S8 start with the rotation of the drawing nets. This rotation is done S7 and S8 to facilitate in constructing the model cube. After that S7 square determine who made the back side of the cube as fixed side, while the S8 square determines who made the lower side of the cube as a model of fixed side. Furthermore, S7 and S8 imagine determining the direction of the folding picture nets, namely inward. After drawing the cube, S7 and S8 imagine the rotation of the cube of the new construction. This rotation is done S7 and S8 to change the position of the cube so that the three sides of the cube signed simultaneously visible from the front. On completion of the first and second, S7 and S8 uses the same reasoning structure, and construct models so as to produce a perfect cube with the correct answer.

Similarly, when constructing the model cube with a sign on the front side of the cube specified models (Task second category), S7 and S8 start with a rotation of the drawing nets. In contrast to the purpose of rotation in the first category of task completion, task completion rotation in the second category is done S7 and S8 to adjust the direction of one of the signs on the image nets with direction signs on the front side of the cube that have been determined. After that S7 and S8 imagine a square determine who made the front side of the cube as a model of fixed side. Furthermore, S7 and S8 imagine determining the direction of the folding picture nets, ie towards the outside. Although making changes to the structured reasoning, S7 and S8 able to construct models so as to produce a perfect cube with the correct answer.

Judging from the framework Subanji & Supratman, A.M (2015) S7 and S8 spatial reasoning are reasoning correctly. Ie reasoning "real" which is based on the logical reasoning process-analytical and produce the correct answer. Meanwhile, if the review of the framework Bergqvist, et al. (2008), S7 and S8 reasoning process is a process of creative reasoning. S7 and S8 are able to make re-order the same reason between the first and second settlement in the first category assignment. In addition, they are able to make new steps in the completion of the task the second category. This means that S7 and S8 adaptation and different approaches to solving different problems. Of each strategy chosen on each of this completion, S7 and S8 can give reasons explaining why the settlement is considered right or make sense of mathematics.

CONCLUSION

Based on the results of the study researchers reasoned process flow of students in constructing the model cube of nets that have been determined, it can be concluded some of the following:

1. In SE spatial reasoning, spatial reasoning grooves subject begins with determining the square is used as a fixed point. In this line of reasoning SE category spatial subjects divided into two categories. First, if the fixed point was chosen is the bottom side model of the cube, then the next subject imagines folding nets (other than a fixed point) towards the inside so constructed cube. After that subjects draw a cube from the particular viewpoint. Recently the subject of a sign on the sides of the cube of the new construction, so three sides of the cube signed simultaneously visible from the front.

   Second, if the fixed point chosen is the front side model of the cube, then the next subject imagine folding nets (other than a fixed point) outward, thus constructed a model of the cube. After that subjects draw a cube from the particular viewpoint. Recently the subject of a sign on the sides of the cube of the new construction, so three sides of the cube signed simultaneously visible from the front.

2. On Double SSCC spatial reasoning, spatial reasoning grooves subject begins with a rotation of the webs and end with the rotation of the cube. Based on the determination of a fixed point, then double SSCC category there are two grooves of different spatial reasoning. First, after a rotation of the image nets, the subject chose the bottom side model of the cube as a fixed point. Furthermore, the subject imagines folding nets (other than a fixed point) towards the inside so constructed cube. After that subjects draw a cube from the particular viewpoint. Furthermore, the subject of a sign on the sides of the cube of the new construction. Subject last rotation against the new cube construction, so three sides of the cube signed simultaneously visible from the front.

   Second, after a rotation of the picture nets, the subject chose the back side of the cube as a fixed point. Furthermore, the subject imagines folding nets (other than a fixed point) towards the inside so constructed cube. After that subjects draw a cube from the particular viewpoint. Furthermore, the subject of a sign on the sides of the cube of the new construction. Subject last rotation against the new cube construction, so three sides of the cube signed simultaneously visible from the front.

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