# Strategies Of Students In Completing Cross-Section Task Of Mathematics Spatial Visualization

Shinta Wulandari[1], Cholis Sa'dijah[2], Edy Bambang Irawan[3]
Universitas Negeri Malang, Indonesia
pmatshintaw@gmail.com,

Abstract: Spatial visualization required so a person's thoughts can be communicated to others. The purpose of this study is to describe the strategies students in completing the task of determining the geometrical cross section cut by one plane. The subjects of this study are five students in the fifth grade of elementary school. These students are required to predict the two dimensional cross-section when a simple geometric solid is sliced by a cutting plane. There are three simple geometric solid, namely spheres, cones and cylinders. The results showed that the emerging strategy is imagistic and analytic strategies. Imagistic strategy refers to (1) encoding the spatial characteristics of an object such as shape, position and orientation in the field of cutting, (2) students imagine slicing object and mentally moving it to focus on a form field pieces and (3) represents a cross section geometrical of the object cut through orthogonal orientation based on their position on the surface of the cut. The analytic strategy is characterized by comparing two stimuli, such as comparing the shape of a circle with a pad on a cone.

Keyword: spatial visualization, cross-section, imagistic, analytic

Spatial visualization was useful for learning geometry (Gecu, 2015; Wai, Lubinski and Benbow, 2009). Spatial visualization is the ability to understand the forms of spatial and to show step by step folds or mental rotation (Wang and Carr, 2014). In geometry, the object being studied is the space. Space is an image of spatial and strategies are needed when students are dealing with spatial image (Ho, Lowrie and Ramful, 2013).

Mathematical problems related to spatial visualization can be completed by students using strategies imagistic or analytic strategies. This strategy can be used simultaneously and can also be used separately (Cohen and Hegarty, 2014). Imagistic strategies can be used to solve mathematical problems when using imagery associated with the shape, position, orientation and perception in general (Ho, Ramful and Lowrie, 2013). Analytic strategies used to resolve visually when using explicit steps to resolve it (Ho, Ramful and Lowrie, 2013, Cohen and Hegarty, 2014).

Imagistic strategy or also called as a visual strategy is a strategy that consists of three steps, namely capture, encode and represent the object being studied (Cohen and Hegarty, 2014). On the task of completing the three-dimensional cross-sectional sliced by a plane, Cohen and Hegarty (2014) states that the first step is carried out with imagistic strategy is to encode the spatial characteristics of an object such as a solid shape in geometry and orientation on the cut plane. The second step is the students visualize the cutting object and moving parts are cut off so the focus among people who are viewed with objects that have been cut. The next step is to make the shadow of orthogonal orientation of the cutting object.

Analytical strategy can be done by comparing the two stimuli. Research by Cohen and Hegarty (2014) concerning the cross-section of cutting the object with plane, stimuli used is cones, cubes, tubes, prisms and pyramids. Ho, Ramful and Lowrie (2013) stated that the analytic strategy that appears in the reflection problem, namely the use of the properties of the object while working on reflection; find the line of symmetry or at the time of constructing symmetrical objects. This study aims to explore strategies that made the subject at the time of completing geometry problems and difficulties that arise when solving problems of geometry.

## METHOD

Subjects in this study were five students in fifth grade of elementary school. Subject coded as S1, S2, S3, S4 and S5. Subjects are given a problem to determine the cross-sectional shape of the three dimensional space that sliced using a flat plane. The three dimensional space in this study are spheres, cones and cylinders. Cross-sectional shape provided in a choice of four answers, students were asked to circle the two dimensional areas is possible. Figure 1 is an example of cross-sectional slices problems between the spheres with a flat plane.

Previous students have been learning about cubes, blocks, cylinder, sphere and cone. They learn about their characteristics, cube nets, and determining their volume. Upon completion of the issue, subjects were interviewed to obtain information of their strategy to solve the problem of completing cross-sectional. The task of completing cross-sectional taken from Santa Barbara Solid Tests.

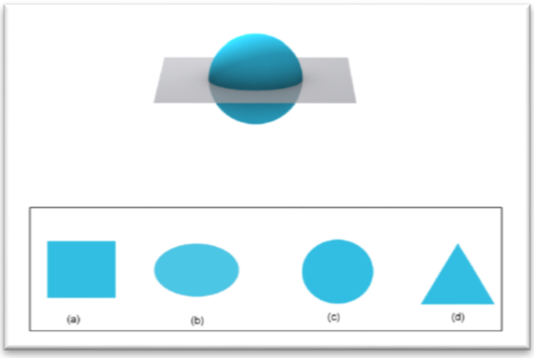


Figure 1: Setting instruments sectional ball is sliced by a flat surface

In resolving the problem of determining the cross section, subjects were given a chance to finish in a maximum time of 15 minutes. Subjects were given the opportunity to check and repair the answer choices when deemed incompatible with the cross-sectional shape mentally visualization. Before starting the decisive cross-section, first submitted that the geometrical cut is solid shaped. While the resulting cross-section is a cross section orthogonal to the area of intersection. As an illustrative example is given in the form of sliced watermelon, after being sliced students are asked to describe the cross-sectional shape when viewed perpendicular to the direction of the slices. All subjects can tell that the cross-section is formed with a circular red color in the circle area and greenish-white color in the area around the red circles. After making sure all the subjects understood the rules of the problem, the subject is welcome to resolve the problem of determining the cross-section.

## Result and Discussion

The five subjects solve all the problems within a period of 15 minutes. After resolving the five subjects were interviewed separately. The problem of determining cross-sectional slices of geometrical completed five subjects is shown in Table 1. Table 1 is the result of spatial visualization subject to the problem of determining the cross-section. Seen in S4, cone sliced cross-sectional shape with a flat surface changes, from the triangle to be a triangle shape with a semi-circle.

Table 1. Result of Cross-Sectional

| Subjek | Sphere | Cone | Cylinder |
|---|---|---|---|
| S1 |  |  |  |
| S2 |  |  |  |
| S3 |  |  |  |
| S4 |  |  |  |
| S5 |  |  |  |

Table 1 also illustrates that subjects tend to choose the same answer, especially S1, S2 and S3. The S4 and S5 tend to choose the same cross-sectional shape in cross-section when solving sphere and cylinder.

Determination sectional sphere is sliced by a horizontal plane, produces two forms of ellipses and circles. According S3 elliptical cross-sectional shape as a circle seen from the side, not perpendicular to the plane of intersection. Here are the results of interviews with S3 associated with the options on the elliptical.

*Obs : Is this the result of the cut?.*
*S3 : yes Mom (pause) ... It's an ellipse.*
*Obs : why selected the ellipse?*
*S3 : the sphere is sliced like this (while demonstrating a flat, cut the sphere by hand), when viewed from here, it is a elliptical shape (while demonstrating the paper in front of her face).*

Determination of the cross-section between cone with areas of flat, two-dimensional plane that has been chosen is a form that is a combination of a triangle with a half circle (see table 1). Subject S4 initially chose a triangular shape, but he decides to change his answer with a cross section combination of a triangle with a semicircle. The reason of S4 is to replace his choice because he is doubtful with a triangular shape. He thought that the triangle does not form a cone. Of the five subjects, the S5 looks very unsure of the answer is that the triangle as a cross-section shape with a flat surface.

The third issue is the determination of cross-sectional slices of the cylinder with a flat surface vertically. The fifth subject determines the form of cross-section is a combination of a semi-circle at the top, rectangular and half-circle at the bottom (see table 1). The first subject (S1) presents the results of his reflection in order to obtain cross-sectional shape chosen.

*Obs : why this form is selected (while pointing at the selected answer)*

*S1 : the top and bottom of the tube continues its center circle cut if I become a rectangle, if combined right so this picture (pointing choice answers)*

Unlike the S1, S3 said that the selection of cross-section shape by comparing what has been learned from previous netting of the cube. He said that the cube is formed by six square. Netting is based on a cube; he concluded that the cylinder consists of three forms so that when cut also produces three flat wake that when put together will form a flat wake as it chooses.

**Strategy in solving the problem sectional slices of geometry with a flat surface**

The strategy resulted in the determination of the cross-sectional slices of geometry with flat areas are grouped into two categories, namely imagistic strategy and analytic strategies. **Im** code on a transcript of the interview showed the subjects were using imagistic strategy, while the **An** code indicates the subject is using an analytic strategy.

Imagistic strategy appears when the subject S2 resolve cross-section of the sphere is sliced by a flat surface horizontally. Here's a transcript of an interview between the observers with S2.

*Obs : tell me how you get a cross-section between spheres with a flat surface*

*S2 : mmm, first I imagine a ball there, continues to exist a kind of paper (Im1) . Paper was used to cut the ball just right in the middle of the ball become two pieces... mmm ... yes two (Im 2). Then ... mmm if separate on the middle invisible (Im 3).*

*Obs: what looks like?*

*S2 : look like ... mmm ... that is a circle. Yes a circle.*

Imagistic strategy of the student when is solving cross-sectional slices geometry with a flat surface. Imagistic strategy done in three steps: (1) imagine geometry (spheres, cones and cylinders), (2) given the physical characteristics that are important from the space, and (3) imagine the space cut with paper (paper representing the horizontal plane) and move it so imagine the result of cuts.

Analytical strategy appeared on the subject S5 when determining the cross-section of a ball with a flat surface. Based on the transcript between the observers with the S5, S5 compares it appears that between the two stimuli, between the spheres with a soccer ball.

*Obs : tell me how you get a cross-section between sphere with a flat surface*

*S5 : I imagine there is a soccer ball sliced by a paper ... (An)*

*Obs : Yes ...go on.*

*S5 : soccer ball broke in two,*

*Obs : what kind of the shape did you see?*

*S5 : the shape is .... (Pause)… like a circle*

**Student difficulties related problem resolution cross-sectional slices of geometry with a flat surface**

The fifth subject at the time to solve the problem sectional has difficulty at the time of spatial orientation. Subject assumes that the cross-section visible is not orthogonal. Visible on determining spatial is orientation of the cross section of the ball. If the ball is not seen as orthogonal to the plane of cutting, the cross section that looks elliptical because of the orientation of the subject is himself the object being cut (Figure 2). Orientation difficulties been faced by S1, S2, S3 when solving sphere cross-sectional. If the orientation of the subject changed orthogonal to the cutting plane, it would appear circular cross section.

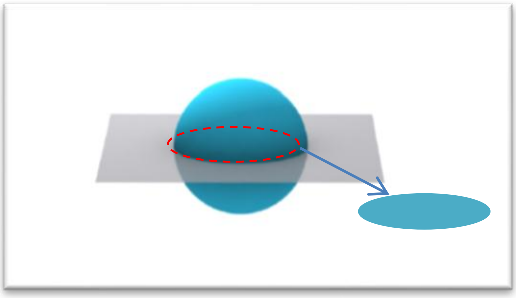

Figure 2 : The sphere is cut flat plane

The cross-section of cones and tubes, especially the subject S1, S2 and S3 seems to visualize partial cross-section. All three subjects make clear that a cone made up of two parts, namely cone and the base of the cone. When the two sections are cut horizontally, then each section will be cut into two there are smaller cones and truncated cones at the bottom. The third subject does not consider that the object should be determined cross-section, but it is happening is the subject focus on the cone cropped by a flat plane. The cone is conceivable seen in a vertical cross-section so that a triangular cone while cone ring-shaped pedestal will be cut into half circles. When two objects vertically cutting results are combined, it will form a triangular field with a semicircular base.

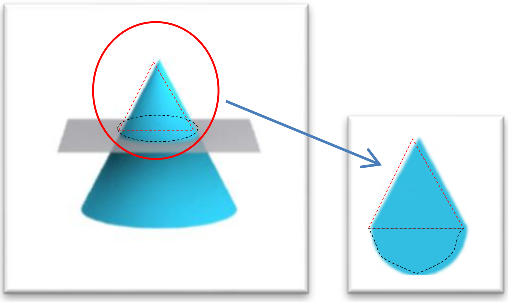

Figure 3: Cross-section of cone by S3

On the task of cross-section of the cylinder that is cut flat field vertically, all subject gives the same information related to it. The cylinder is divided into three parts, namely cylinder surface, cylinder cover and cylinder pedestal. Cylinder truncated rectangular, the cover and the base of each tube-shaped circle if the cut will semicircular. So that when fully assembled will form a rectangle with two half circles at the top and the base of the rectangle.

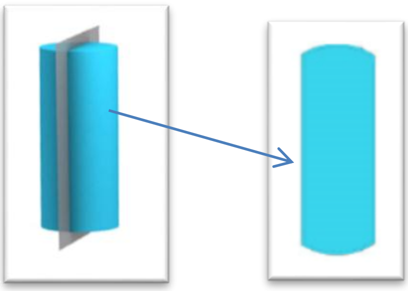

Figure 4 : Cross-Section of the Cylider by S1

Difficulties on the subject indicated that at previous lesson they learned cube net. Net cubes are separately square and then assembled into a single geometry. Errors in spatial visualization in this case are likely due to previous subjects learned the concepts net cube so that the subject thinks partially to the problem of determining these cross sections.

## CONCLUSION

When performing spatial visualization, through this study showed that the strategy used at the time to solve the problem of determining cross-sectional geometry with a flat field grouped in imagistic strategy and analytic strategies. Imagistic strategy characterized by the encodings, imagines the movement of field pieces, and represents the cutting results by field pieces. Analytical strategy is characterized by comparing the two stimuli in this case the stimuli used is a sphere with a soccer ball.

## REFERENCES

Cohen dan Hegarty. 2014 Visualizing cross sections: Training spatial thinking using interactive animations and virtual objects. *Learning and Individual Differences 33 (2014) 63–71*, journal homepage: www.elsevier.com/locate/lindif.

Gecu. et. al. 2015. Effects of computer game experiences on children's spatial abilities. *International J. Soc. Sci. & Education Vol.5 Issue 4*, www.researchgate.net/publication.

Ho, S.Y., Lowrie, T. dan Ramful, A, 2013. Visual and Analytical Strategies In Spatial Visualization: Perspectives From Bilateral Symmetry and Reflection, *Proc.36th Psycology Mathemathic Education, Vol. 3, 311 – 320.*

Wang dan Carr. 2014. Working Memory and Strategy Use Contribute to Gender Differences in Spatial Ability, *Educational Psychologist, 49(4), 261–282*, www.researchgate.net/publication.

Wai, L., dan Benbow. 2009. Spatial Ability for STEM Domains : Aligning Over 50 Years of Cumulative Psychological Knowledge Solidifies It's Importance. *Journal of Educational Psychology Vol.101. No.4 817-835*, www.researchgate.net/publication.