The blind student’s interpretation of two-dimensional shapes in geometry

Andriyani¹, I K Budayasa² and D Juniati³

¹ Mathematics Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
²,³ Mathematics Education, Universitas Negeri Surabaya, Surabaya, Indonesia

E-mail: andriyaniandriyani@mhs.unesa.ac.id

Abstract. The blind student’s interpretation of two-dimensional shapes represents the blind student's mental image of two-dimensional shapes that they can’t visualize directly, which is related to illustration of the characteristics and number of edges and angles. The objective of this research is to identify the blind student’s interpretation of two-dimensional shapes. This research was an exploratory study with qualitative approach. A subject of this research is a sixth-grade student who experiencing total blind from the fifth grade of elementary school. Researchers interviewed the subject about his interpretation of two-dimensional shapes according to his thinking. The findings of this study show the uniqueness of blind students, who have been totally blind since school age, in knowing and illustrating the characteristics of edges and angles of two-dimensional shapes by utilizing visual experiences that were previously obtained before the blind. The result can inspire teachers to design further learning for development of blind student geometry concepts.

1. Introduction
In elementary school, visualization becomes one of the important ability used to help students in understanding spatial concepts, shapes, sizes, and distances. However, blind students lose visual aid to learn the concept of geometry. Losing of visual experience in blind students causes some difficulties in obtaining the concept of geometry directly.

According to Thinus-Blanc [1], blind students take a long time to construct mental representation of the spatial concept so that geometry is not easy to be taught. In the other result of the study, Vianna [2] also showed that students with visual impairment such as blind students have difficulty of geometry images understanding.

The difficulty of learning geometry is not only experienced by students, but also experienced by teachers who teach this subject. Although using tools in physical models, many teachers have difficulty to instruct geometry to blind students who can’t use visual sense (Pritchard) [3].

On the other hand, the difficulty of blind students in geometry also caused by the limitations of geometry books in Braille format as well as geometry learning media that suits the needs of blind students. In fact, the difficulty of gaining access to information also still experienced by the blind as a minority (Abner) [4]. Even though, blind students are granted to access of information just like a normal student, like Augusto and Colford’s statement [5, 6].
Several experience of difficulty by the blind students does not mean eliminating opportunities for visually impaired students to study geometry at the school since it is mentioned by Government which rule number of 72 in 1991, that Indonesian mathematic curriculum at SLB (physical defect school) is the same as the Indonesian mathematic curriculum with the normal students. With the same curriculum as normal students, teachers need specific strategy to teach mathematic that have abstract concept in the blind learning. For that reason, teachers must know how the interpretation of blind students related to their understanding of the geometry’s concepts. The question of how the blind student's interpretation of the two-dimensional shapes as one of geometric concepts is interesting for the researcher. Therefore, this study aims to identify the interpretation of blind students of two-dimensional shapes in geometry, whereas blind students loss visual sight to observe images or geometry models. From the interpretation of blind students, it is expected to know how the understanding of blind students and obstacles are experienced, so that teachers can find strategies and learning media in accordance with the needs of geometry learning for blind students. Furthermore, from the student's interpretation, it is expected to identify how the abstract concept of two-dimensional shapes has been related with real objects that blind students experience it every day.

2. Theoretical Background

2.1 Interpreting on Cognitive Processes

According to Anderson [7], students are classified to understand a concept when they can construct the meaning of the concept that has been learned involving some cognitive processes. One of the most important cognitive processes in understanding is interpreting.

In the cognitive process of interpreting, a student is classified to be able to interpret an idea if he can interpret information or idea by communicating it to a different form of communication through the way of language. Interpreting an idea means explaining what is in his mind about the idea so that the student's interpretation can be an explanation that represents his mental picture. This interpretation depends on the relevant knowledge that the student has. Students who can interpret each part of the idea with their knowledge will be able to relate these sections to a more complete thinking activity. This student's interpretation can be seen from an internal representation that describes something in his mind as suggested by Izsak [8]. In line with that, Michaelidou [9] also proposed that representation has an important role to represent students’ mathematical ideas in understanding mathematical concepts of students.

To be able to interpret a concept which is learnt, each student has a different ability that is influenced by his or her cognition, especially conception. The factors that affect individual cognition are: the physical and social environment, physiological structure, willingness and goals, also experiences in the past Krench [10].

2.2 Bind Student’s Concept Development

Visually impaired blind physiology is the loss of the senses of vision that impact on differentiation in the development of the concept. According to Ashkenazy [11], visual impairment will make a visually impaired person unable to develop his social behaviour just like any person who uses visual experience.

Concerning to the development of the concept of the blind according to Dick and Kubiak [12], the development of a blind concept depends on the level of blindness and age of blindness so that a blind person who had a visual experience before they blind, can at some point utilize his or her visual experience to understand a particular concept. A blind student will develop his conception (especially for the concept of physical objects) more through tactual experience, while the normal students through visual experience (Lowenfeld ) [13].

For visually impaired students, tactual experience is gained by using palpable as a surrogate sensitivity that has a special sensitivity in the acquisition of visual information, such as a shape of the image or exploring the physical objects. The tactile or tactile capabilities involved in information processing by a visual impairment are influenced by tactual perceptions: synthetic perceptual perceptions and perceptible analytic perceptions as Lowenfeld’s statement [13]. Perception of the blind
students is obtained by the functioning of the sense of touch. This palpable sense is the widely use sensory impairment to help him modify and manipulate nearby objects as conveyed by McLaughlin [14].

The importance of tactual perception as a special form of belonging to this blind student is in line with the results of the research conducted by Argyropoulos [15] which showed that in the geometric stage of blind students, there is a complexity of tactual perception as a uniqueness in thinking activities of blind students related to the development and understanding of a concept formed. Furthermore, the suitability of the geometry of thinking stages of students related to their understanding of a concept of form, such as planar shapes, with Van Hiele's theory, in accordance to the research from Gray and Tall [16]. From the results of his research related to students' activities in understanding the concept of planar shapes, students recognize the build-up triangle or quadrilateral by observing the characteristics of the same or different from of the object in the form of the planar shapes. While in the other hand Tilman [17] showed that blind students are less able to integrate all types of facts that they have learned so that any information received is as if stored in a separate frame of reference from other information because they lose sight that facilitates them to connect different experiences - relationships and relationships that help them selectively harness experiences when the formation of perceptions happened, especially regarding the understanding of objects.

The activity of interpreting in this study refers to the process of cognition involved in understanding of the concepts proposed by Anderson [7]. In interpreting, the student explains the mental picture that is in his mind through his own way and language.

3. Method
This research was an exploratory study with a qualitative approach to identify the blind student's interpretation of two-dimensional shapes in geometry. The question of interviews consisted of questions about subject’s interpretation of two-dimensional shapes especially square and rectangle. Subjects chosen were employed as a source of qualitative data, and they are fourth-grade student who experiencing a total blind since the fifth grade of elementary school from SLB-A YPAB Tegalsari Surabaya city. Data on the blind student's interpretation of the two-dimensional shapes were collected by means of task-assisted interview and the interviews were carried out two times by using equivalent problems on two different times. Student is assigned to give examples of the two-dimensional shapes that they know and to give the reason. When he mentioned the examples, student asked to illustrate the example in their own way, for example by drawing the shapes. The data collected from the interviews were then classified, reduced and validated by using triangulation methods to yield credible data. The credible data were analysed by using qualitative research analysis data method including data display interpreting and conclusion drawing as Miles and Huberman’s statement [18].

4. Results
From the results of interviews and observations the researchers conclude that the subject analogized the square's shape with objects that they knew every day, namely the box. According to the subject, square was a flat shape, shape which has four edges with equal length and right angles. In detail, the subject explained that the four edges of the equal length were one on the left, one on the right, one on the top, and one on the bottom. The end of each edge met the other vertex. The edges that the subject recognizes as characteristic of the shape were interpreted as the shape's boundary, whereas the right angles were interpreted as an angle formed by two edges; the perpendicular and horizontal edges.

When the subject was asked about square's example that’s he knew, the subject said that the floor tile surface was a square's example because the four edges of the tile are the equal length and angle of the tiles is right angles. Next, the researcher asked the subject to illustrate his interpretation of the two-dimensional shapes as described earlier. He illustrated his interpretation by using a paper and a pen to draw a square. The subject drew a vertical line from top to bottom along the edge of his index finger with a size of about 3.5 cm. Then the subject drew a horizontal line that starting from the end of the
previous line from left to right and the length is almost the same. In the same way, the subject drew the third and fourth lines, as shown in Figure 1.

![Figure 1. Figure of square](image1)

The subject explained his reason for illustrating a square like figure 1 because the shape in the figure has characteristics of the edges with equal length and angles as a square. Researcher asked the subject to show the characteristics of the edges and angles of the subject referred to in Figure 1. The subject fingered his drawing that he made previously and back to draw because there was line that did not intersect at one the vertex, as in figure 2.

![Figure 2. Figure of square after revised](image2)

The two-dimensional illustrations which are illustrated by the subject showed that the subject knew a square as a simple closed curve having right angles.

From the interviews and observations, the researcher also found that subject interpreted the rectangular shape as a flat shape, it has two opposite edges of equal length and two opposite edges of equal short, also a right angles. Each end the vertex of length edges met the adjacent end to the vertex of another short edge. The two opposite edges of equal length and equal short were interpreted as edges having sizes of equal length and parallel as shown by the subject by hand in Fig. 3.

![Figure 3. Figure hand-on of opposite edges by board-markers](image3)

The rectangular angle is interpreted as an angle formed by two adjacent perpendicular edges to each other as the subject represents by hand on Figure 4.
Figure 4. Figure hand-on of right angle by fingers

When the subject was asked to give the example of rectangular which has known, subject said that the door surface was a rectangular example because two edges of the door surface were the same length and the other two edges were equally short. Besides that, angles of the door surface were right angle. Next, the researcher asked subject to illustrate his interpretation of the two-dimensional shapes as described earlier in another way. The subject asked for a paper and a pen to draw rectangle. Subject drew a vertical line from top to bottom along the edge of his index finger with a size of about 4 cm. Then the subject drew a horizontal line that start from the end vertex of previous line from left to right with a size of about 2.5 cm. In the same way, the subject drew the third and fourth lines, as shown in Figure 5.

Figure 5. Figure of rectangle

The subject explained the reason to illustrate the rectangle as in figure 5 because the shape of the image has the same characteristics edges and angle as the rectangle. The researcher asked subject to show the characteristics of the edges and angles that referred to in Figure 5. He fingered the drawing and improved the previous drawing because there was a line that wasn't intersect at one vertex or does not form an angle, like showed in figure 6.

Figure 6. Figure of rectangle after revised

The two-dimensional shapes illustration showed that the subject knew about rectangular. It is a simple closed curve that having four angles likes a rectangular.

5. Discussion and Conclusion

From the results of the study it is shown that by using the language and the way the students blind totally blind after birth interpret the two-dimensional shape, especially the square and rectangle, as flat, flat, high, and have certain side and angle characteristics. The activity of interpreting this phenomenon according to the cognitive process interprets the concept of understanding which is expressed by Anderson [2].

In interpreting a two-dimensional form, student associates a real object that has similar characteristics to that two-dimensional form. This shows that students' perceptions are influenced by certain knowledge or experiences that they gained as presented by Krech [10].

Student representation by using props to illustrate the characteristics of two-dimensional shapes also indicates that students have gained certain experience with the characteristics of the represented form. In addition, a detailed explanation of students in describing the characteristics and examples of real objects
that are known to form two-dimensional, also shows the role of certain experiences that affect the perception and development of student concepts.

The experience of the student is not only affects his perceptions of a particular object, but also influences the development of blind student’s concepts that are highly depend on the level of blindness and age of blindness as presented by Dick and Kubiak [7]. This is evident from the results of research showing that the visual experience of a blind student with total blindness since he born has an important role in the way he illustrates or describes a two dimensional shapes. The student draws the up-side along the index finger assumed as a ruler. The experience of using a ruler, obtained by blind students before he experienced blindness. This is a unique case that the blind student has to measure the length of the side and creates a straight line that is interpreted as the side. The shape and the length of the subject line explored by using tactual ability through its sense of touch as a substitute for the sense of sight as was presented by McLaughlin [12]. According to Argyropoulos[3], tactual perception that is used by blind students is a uniqueness in blind student's thinking activity related to its development and understanding to a concept of form.

Based on the results of the study, it can be concluded that students with total blindness after birth interpret the two-dimensional form as a flat form, having no height, having characteristics of side length and certain angle type. The representation students use to represent their interpretation of the two-dimensional form shows that the perception and development of the concept is influenced by the experience before blindness, and the representation shows the uniqueness of the blind students in understanding a two dimensional shapes.

References

[1] Thinus-Blanc C and Gaunet F 1997 Psychological Bulletin12120-42
[2] Vianna C S, Barbosa P M, Rocha D F and Silva B 2008 Teaching Geometry for Blind and VisuallyImpaired Students
[3] Pritchard C K and Lamb J H 2012 Journal of Mathematics Teacher106pp22-27
[4] Abner G H and Lahm E A 2002 Journal of Vision Impairment and Blindness 96p 2
[5] Augusto C and Schroeder P 1995 Journal of Visual Impairment & Blindness 89p 9
[6] Colford M 2000 Library Journal 125 p 122
[7] Anderson L W and David R K 2001 A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives (Boston: Pearson Education Group)
[8] Izsák A 2003Journal for Research in Mathematics Education 34 pp191–227
[9] Michaelidou N, Gagatsis A, and Pitta-Pantazi D 2004 Journal for Research in Mathematics Education38pp173-192
[10] Krech D, Cruchfield R S, and Ballachev E L 1982 Individual in Society (Berkeley: McGraw-Hill International Book Company)
[11] Ashkenazy E C A, Ophir-Cohen M, and Tirosh E 2005 Journal of Visual Impairment and Blindness 99pp478-485
[12] Dick T and Kubiak E 1997 The Mathematics Teacher 90pp344-349
[13] Lowenfeld B 1973 History of the Education of Visually Handicapped Children (New York: JohnDay Co)
[14] McLaughlin M, Hespanha J, and Sukhatme G 2002 Touch in Virtual Environments: Haptics and the design of interactive systems (Upper Saddle River, NJ: Prentice Hall)
[15] Argyropoulos, V S 2002 British Journal of Visual Impairment20 1 7-16
[16] Gray EandTall D2007 Mathematics Education Research Journal19 23-40
[17] Tilman M H 1969 International Journal for the Education of the Blind 3 5-7
[18] Miles M B and Huberman A M 1994 Qualitative Data Analysis 2nd an Expanded Source Book (California: Sage Publication)