The Investigation of Blind Students' Misconception in Constructing Quadrilateral Analytic Definition Using Geometry's Puzzle

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Abstract. Many students still possessed misconceptions and not yet know the relation between each quadrilateral, no exception blind students that have abnormal physiological structures. Lack of student' ability in relational thinking makes it difficult to construct analytic definitions that contain the closest type (genus proximum) and special differentiator (differentia specifica) on the objects. The aim of this study is to investigate the misconceptions of blind students in constructing the analytic definition of a quadrilateral using geometry's puzzles. Misconception investigations focus on misconceptions of students' concept or differences of student' scientific understanding with the expert conceptions, especially misconception in constructing analytic definitions. This research is an exploratory study with a qualitative approach and the subjects of this study are one seventh grade student who experienced totally blind and one student who low vision from MTs Yaketunis Yogyakarta. Data collection through task-based interviews and observations. Before being analyzed, the obtained data then transcribed, classified, reduced and validated using the time triangulation method. Based on the results of data analysis, it is known that both of blind students have misconceptions namely classificational, relational and theoretical misconceptions with the level of misconception in low vision student lower than totally blind.

1. Introduction

Changed the educational paradigm to a learning society requires the existence of universal learning principles that underlie education to deal with these changes [1]. To cope with the world changed into the Twenty-First Century, students need to know how to use their knowledge and skills by thinking critically, applying knowledge to new situations, analyzing [2].

The results of the PISA (Program for International Student Assessment) showed that Indonesian students still had difficulty in applying mathematical concepts in contextual issues which are one of the demands of Twenty-First Century learning [3]. This is caused by learning which emphasizes procedural and monotonous knowledge, so mathematics is considered a difficult subject by most students [4]. One branch of mathematics that is subject to study in school mathematics subjects and has the potential for difficulties for students in geometry. Geometry is more familiar and has a great opportunity to understand for students because of the introduction of basic concepts and geometry models they already get through objects that often saw in their informal education environment. Even so, there are still many students who make mistakes in learning geometry especially in a two-dimensional shape [5]. One of the mistakes is caused by the misconception of the concept meaning that is characteristic of learning itself. Conception is generally built on common sense or intuitively to make sense of something.

The misconception is very difficult to change because a person constructs his own knowledge which is influenced by differences in individual thinking, methods of delivering material by the teacher or learning resources used by students. The misconception that comes from the student is caused by the incompatibility of the initial concept student have with scientific concept. While misconception that comes from the teacher or learning resource is caused by a lack of understanding concepts taught and lack in the resources learning preparation. These misconceptions can be an obstacle to students understanding concepts well. Several types of misconceptions are viewed from students' visual-spatial intelligence, namely theoretical misconception, classificational misconception and correlational misconception [6].

According to [7], students experience misconception on the quadrilateral definition and assume that the quadrilateral only in a regular shape. If the quadrilateral concept of students experiencing misconception, students can have difficulty understanding more complex concepts because the geometry concept has a hierarchical structure and is spiral. According to [8], generally students were very capable of solving the calculating or measuring problem in the quadrilateral and perimeter, but whenever teacher asked questions that required them to analyze or synthesize the relationship between the measurements, they ran into problems. Their typical response that they had some misconceptions which needed to be addressed. It means they not really understanding about the quadrilateral concept but recall only. Students haven't been able to identify similarities or differences in the characteristics of each quadrilateral and then be classified in the closest type (genus proximum) and special differentiator (differentia specifica), so it can be seen the relation between quadrilateral with each other. The students' inability in relational thinking can make it difficult for students to construct analytic definitions that contain the closest type (genus proximum) and special differentiator (differentia specifica) on the related object. This shows that quadrilateral learning has problems for students to learn especially the student that can't optimize their learning ability like blind students who have a limitation of visualization or visual sensory acceptance [9].

With these physiological structure abnormalities, blind students possess the problems in understanding geometry picture [10]. This constraint can also be difficult for a teacher who teaches concept especially those related to geometry learning strategy instruction, although using physical models [11]. Limitation and obstacle in learning geometry aren't obstacles to continue teaching geometry to blind students because in the Minister of Education and Culture Regulation No. 157 of 2014 has been arranged the content of the special education curriculum for blind students is equated with the content of the regular education curriculum. Thus, the content of geometry material such as quadrilateral must also be taught to blind students.

The reasons about quadrilateral that is part of the geometry in the mathematic subject and there are still problems in learning geometry for blind underlie researcher to conduct next investigation about the conceptual misconception that might occur in quadrilateral learning by blind students. The misconception investigation is focused on misconception related to identifying the closest type (genus proximum) and special differentiator (differentia specifica) in the quadrilateral which is then used to construct the analytic definition constructed by the closest type (genus proximum) and special differentiator (differentia specifica). So this study aims to investigate the misconceptions of blind students in constructing quadrilateral analytic definition using geometry's puzzle. Misconception investigation is defined as an investigation conducted to detect student learning that is estimated to experience misconceptions of concept so that students' conceptions differ scientifically from the conception of experts.

2. Method

This research is an exploratory study with a qualitative approach that aims to investigate the misconceptions of blind students in constructing the analytic definition of a quadrilateral by using geometry's puzzle. Interview questions consist of the subject's construction about quadrilateral analytic definitions namely, parallelogram, rhombus, rectangle, and square. The subjects chosen as the source of qualitative data were one of the seventh-grade who experienced total blindness and one of the low vision blind students from MTs Yaketunis which is a school for exceptional children in Yogyakarta. Data on how blind students' constructing about quadrilateral analytic definitions were collected through task-

based interviews and observations that conducted twice using equal problems at two different times. Subjects were assigned to recognize the quadrilateral shape models in the form of a geometry's puzzle for a parallelogram, rectangle, rhombus, and square given by the researcher. Then, they are assigned to define each of these shapes in terms of the elements of the closest genus and its specific differentiator.

Data collected from interviews are then transcribed, classified, reduced and validated using the time triangulation method to produce credible data. Credible data were analyzed using qualitative data analysis research methods including interpretation of data display and conclusion that can be inferred [12].

3. Result and discussion

Based on the results of the data validation of interviews and observations of two blind students, obtained data about various misconceptions experienced by students in constructing quadrilateral analytic definitions. From several indications of misconceptions in terms of visual-spatial intelligence, namely classificational misconception, correlational misconception, and theoretical misconception, each student has a different misconception in constructing quadrilateral analytic definitions that contain the closest type (genus proximum) and special differentiator (differentia specifica). The following presented the results of the misconception analysis of blind students in constructing analytic definitions using a geometry's puzzle consisting of parallelogram, rectangular, rhombus and square models as follows.

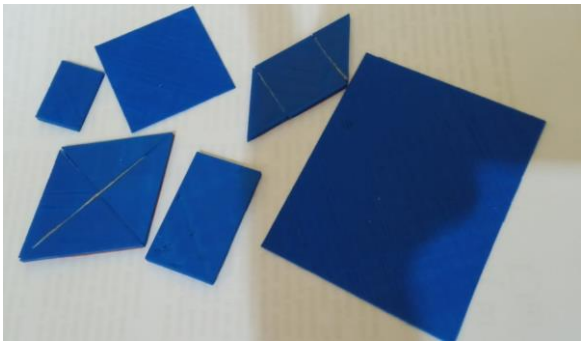


Figure 1. Geometry's puzzle

The totally blind student has a classificational misconception which is a form misconception of facts classification into organized charts. This is seen when a student asked to determine which geometry's puzzle belongs to parallelogram. The student made a mistake in determining the geometry's puzzle included into a parallelogram, he didn't insert rectangular, rhombus or square into the parallelogram. The student even put parallelogram into the rectangle. In classificational misconception, the student also makes a mistake when determining geometry's puzzles that are included in the rectangle. He didn't put the square into parallelogram but instead, put the rectangle into the square. Furthermore, the student also makes a mistake in determining the geometry's puzzle included into the rhombus, he doesn't insert a square into the rhombus. The student just the opposite inserts the rhombus into the square.

Besides classificational misconception, totally blind student also possesses a correlational misconception which is a form of the misconception of special events that are interconnected. This can be seen when the student makes a mistake in explaining the relation between the parallelogram and the rectangle like to interview result below.

Researcher: In your opinion, do the rectangles and parallelogram have similarities or differences in the characteristics of the shape?
Subject (A): Yes
Researcher: What characteristics are the same or different in both?
Subject (A): The same side of the opposite is equally long and some are short
Researcher: What do you mean?

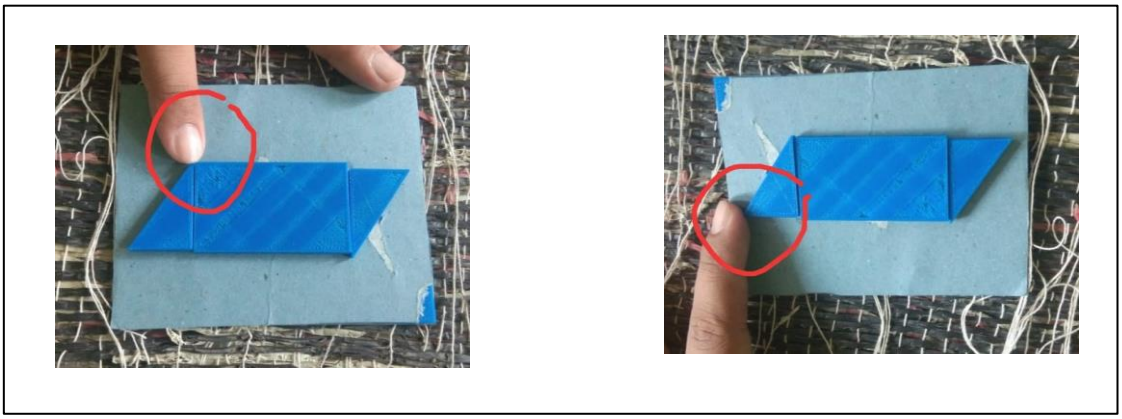
Subject (A): There are two opposite sides that are equally long, then there are two opposite sides that are both shorter
Researcher: How about the difference?
Subject (A): The difference is that the parallelogram is a rectangle whose sides are slanted
Researcher: What about rhombus? Does he have the same similarities or differences as parallelogram and rectangle?
Subject (A): There are no similarities because of both shapes different in all their characteristics
Researcher: How about square and rectangle?
Subject (A): The rectangle is a square that has a longer side measure.
Researcher: What about rhombus and square?
Subject (A): Both are the same side and angles the rhombus is a square that positioning slanted

From the interview, it known that student assumes about the rectangle isn't parallelogram, but the parallelogram is a rectangle. In addition, the student also can't explain the relation between parallelogram and rhombus because both of there are different. Another correlational misconception is the student's mistake in explaining the relation between a square and rectangle because he assumes that the rectangle is a square that has a longer side. Others, the student also make a mistake in explaining the relations between rhombus and square because he assumes that rhombus has the same side length and angle type. The student also assumes the rhombus is a square that is positioned slant

The totally blind student has a classificational misconception which is a form misconception of facts classification into organized charts. This is seen when a student asked to determine which geometry's puzzle belongs to parallelogram. The student made a mistake in determining the geometry's puzzle included into a parallelogram, he didn't insert rectangular, rhombus or square into the parallelogram. The student even put parallelogram into the rectangle. In classificational misconception, the student also makes a mistake when determining geometry's puzzles that are included in the rectangle. He didn't put the square into parallelogram but instead, put the rectangle into the square. Furthermore, the student also makes a mistake in determining the geometry's puzzle included into the rhombus, he doesn't insert a square into the rhombus. The student even inserts the rhombus into the square.

Besides classificational misconception, totally blind student also possesses a correlational misconception which is a form of the misconception of special events that are interconnected. This can be seen when the student makes a mistake in explaining the relation between the parallelogram and the rectangle, he assumes that the rectangle isn't parallelogram, but the parallelogram is a rectangle. In addition, the student also can't explain the relation between parallelogram and rhombus because it is different. Another correlational misconception is the student's mistake in explaining the relation between square and rectangle because he assumes that the rectangle is a square that has a longer side. Others, the student also make a mistake in explaining the relations between rhombus and square because he assumes that rhombus has the same side length and angle type. The student also assumes the rhombus is a square that is positioned slant.

Another misconception possessed by totally blind is a theoretical misconception which is a form of misconception about the explanation of facts or events in an organized system and concerns the development process from that known until that unknown by the student. It has seen when the student not exactly in making an analytic definition of parallelogram shape. According to the student, the parallelogram is a rectangular shape that is slanted by its sides and the angles are all pointed or have no obtuse angles. These results are in line with the Ningrum's result [7] related to students' misconceptions that still assume parallelogram is a sloping rectangle. The student also assumes that all angles that have pointed ends are acute angles, while angles that have curved lines are obtuse angles. Students' interpretation of the acute angle and obtuse angle is a form of incompatibility of the concept of angle that student has with the scientific or mathematical concept because the acute angle is an angle whose magnitude less than 90 degrees while the obtuse angle is an angle whose magnitude greater than 90 degrees and less than 180 degrees. Misconceptions about acute and obtuse angles are seen from the similarity of the student show to acute and obtuse angles in the parallelogram puzzle as one type of acute angle as follows.



(a) (b)

Figure 2. (a) - (b). Angles that student interpreted as acute angles

Another theoretical misconception that student isn't exactly in makes an analytic definition of rectangular shape because according to him the rectangle isn't a parallelogram otherwise, the parallelogram is a rectangle. Students are also not exactly to makes an analytic definition of rhombus because according to him rhombus isn't a parallelogram. Inaccurate to make analytic definitions also done by the student when he said that the square isn't a rectangle, but the rectangle is a square. He said too that the square is not a rhombus, but the rhombus is a square. All of this interpretation indicates inaccurate of student-constructed quadrilateral analytic definitions because the analytic definitions that should be student construct are as follows:

The rectangle is a parallelogram whose one angles is the right angle
The rhombus is a parallelogram whose four sides are the same length
The square is a rectangle whose four sides are the same length or a parallelogram whose one angle is the right angle and has four the same length sides.
The square can also be defined as a rhombus whose one angle is the right angle or a parallelogram which has four sides that same length and a right angle.

This in line with the analytic definition criteria by [13, 14] about the analytic definition that rests upon must be stated in term of the closest type (genus proximum) and special differentiator (differentia specifica). The analytic definition of a quadrilateral with the closest type (genus proximum) is "parallelogram" while it special differentiator (differentia specifica) is the information contained rearward the word "whose".

Different misconceptions possessed by low vision student. Low vision student also has a classificational misconception which is a form misconception of facts classification into organized charts. This can be seen when the low vision student asked to determine which geometry's puzzle belongs to parallelogram. In determining the geometry's puzzle that is included into the parallelogram, the student makes not the same mistake as a totally blind student because he doesn't put the parallelogram into the rectangle but he distinguishes between the rectangle and the parallelogram. In classificational misconception, the student makes a mistake when determining geometry's puzzles that are included in the rhombus. He didn't put a square into the rhombus but instead, put a rhombus into the square.

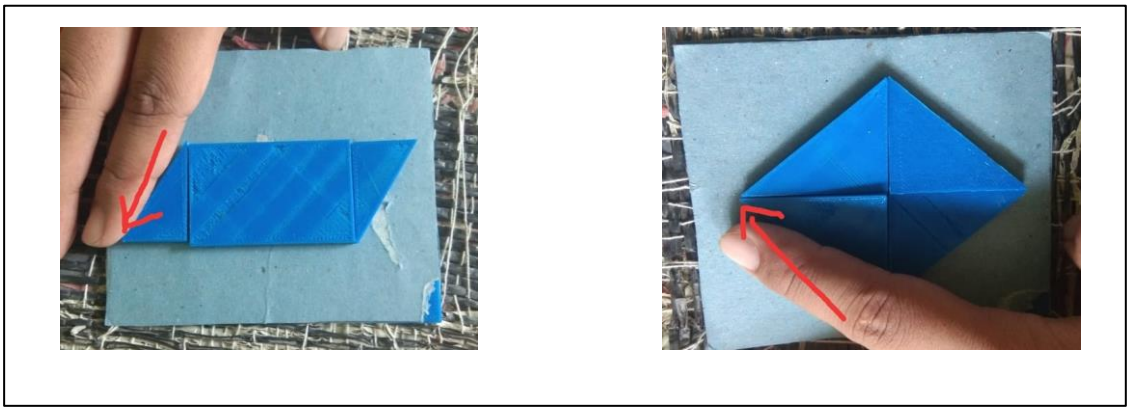
Besides classificational misconception, low vision student also has a correlational misconception which is a form of the misconception of special events that are interconnected. This can be seen when the student makes a mistake in explaining the relation between the parallelogram and the rectangle like to interview result below.

Researcher: In your opinion, do the rectangles and parallelogram have similarities or differences in the characteristics of the shape?
Subject (B): Yes, I think
Researcher: What do you mean? Do you think there are have the same or different characteristics?
Subject (B): Both are different. The parallelogram is not a rectangle or otherwise, but both shapes have the opposite sides which the same length
Researcher: What about rhombus? Does he have the same similarities or differences as parallelogram and rectangle?
Subject (B): Yes, there are have similarities because both have the same characteristic related to the four acute angles it has
Researcher: How about square and rectangle?
Subject (B): The square is a rectangle that has a shorter side measure. I think a square is a shorter rectangle
Researcher: What about rhombus and square?
Subject (B): Both are the same length of side and type of angles, so I think the rhombus is a square that positioning slanted

From the interview, it is known that the student not knowing that a rectangle is a parallelogram. He also can't exactly to explain the relation between parallelogram and rhombus because he assumes that both have the same characteristic related to the sum of acute angles that both have. Another correlational misconception is the student's mistake in explaining the relation between square and rectangle because he assumes that the square is a rectangle that has shorter sides. Nevertheless, implicitly student can already be said to be able to classify a square as a rectangle. Others, the student also makes a mistake in explaining the relation between rhombus and square because he assumes that rhombus has the same side length and angle type. The student also assumes the rhombus is a square that is positioned slant.

Another misconception possessed by low vision student is a theoretical misconception which is a form of misconception about the explanation of facts or events in an organized system and concerns the development process from that known until that unknown by the student. It has seen when the student not quite exactly in making an analytic definition of a parallelogram. According to him, the parallelogram is a quadrilateral that sides are slant or have acute angles and other is non-acute angles. Implicitly student can already identify that the parallelogram has two pairs opposite angles that equal magnitude that is a pair of acute angles and a pair of obtuse angles that are represented as a non-acute angle. Non-acute angle interpreted by the student as another type of angle that his unknown.

Another theoretical misconception that student is not quite exactly in making an analytic definition of a rectangle because according to him the rectangle and parallelogram have the same characteristics, namely the opposite sides which the same length but the rectangle isn't a parallelogram. The student also not quite exactly in making an analytic definition of rhombus because according to him rhombus is a parallelogram whose all angles are the acute angle with the same magnitude, not related to the length of the sides measure. Misconceptions about all the same acute angles on the rhombus and the similarity of the acute angles between the parallelogram and the rhombus can be seen from the similarity of the student show the acute angles to parallelogram' puzzle and one of the acute angles that assumed represent fourth other acute angles on the rhombus puzzle as follows.



(a) (b)

Figure 3. (a) - (b). The acute angles on the parallelogram and rhombus are assumed to be equal

Inaccurate to make analytic definitions also done by the student when he said that a square is a shorter rectangle. Implicitly it also shows that student has been able to identify the closest type of a square as a parallelogram whose one angle is the right angle or a square is a rectangle. The last theoretical misconception is inaccurate to make analytic definitions of a rhombus that said is a square that is positioned slant.

The misconceptions above originated the characteristics of the quadrilateral shapes where student have a misconception of the characteristics contained in each quadrilateral shapes. This in line with the theory explained by [15] that misconception is defined as the perception that has very different or not appropriated meaning with experts' opinion on a certain scientific concept.

Although the analytic definition constructed by blind students is not entirely correct but blind students can already identify the relation between several quadrilateral shapes based on the characteristics of each shape. This in line with the result of Andriyani' research [16] which shows that blind students not only respond to the syntax of the definition but also try to be able to interpret the object imagined even though the formal definition formed hasn't entirely correct as of the formal definition of mathematics.

In addition, the differences of misconception in both of blind students are caused the construction difference of meaningfulness when students interpret each quadrilateral in their own way according to their language, culture or previous learning experiences. The blind student's way to construct an analytic definition with a geometry's puzzle mostly through manipulated the quadrilateral model using its tactual ability to recognize quadrilateral characteristics. This in line with the results of Argyropoulos' research [in 17] that the uniqueness of blind students' thinking activities related to their cognitive development and understanding of shapes concept that carried out using their tactual perception.

4. Conclusion

From the results of research, it can be concluded that both of blind students have misconceptions in constructing quadrilateral analytic definitions, be it classificational, correlational or theoretical misconceptions. Misconceptions by totally blind student tend to be inaccurate to construct analytic definitions and inability' student to explain the relationship of a certain quadrilateral with other quadrilaterals. While low vision student tends to be less precise to construct analytic definition or explaining the relation between each of quadrilaterals because in implicitly he has been able to identify the characteristics of almost all quadrilateral shapes but in classification, there is a less precise in classifying quadrilateral into quadrilateral which is assumed to be the closest genus. As a result, low vision student has classificational, relational and theoretical misconceptions that lower-level misconception than the totally blind student.

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