The Ability of Mathematical Connections to Deaf Students in Completing Math Test

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Abstract: The purpose of the study was to explore the ability of deaf students in grade VIII to complete math connection test of inter-topics in mathematics. The type of research used is qualitative research with a case study and grounded theory design. Data were collected by various methods from six subjects who were taken purposively based on the characteristics of language and speech, intelligence and social-emotional. They were spread in three schools namely; SMPLB Karya Murni Ruteng - East Nusa Tenggara (NTT), SMPLB Negeri Semarang and SMPLB Don Bosco Wonosobo. The results of the analysis showed (1) in building an understanding of the problem, deaf students tend to represent the problem in the form of images and concrete objects. (2) in making initial plans to complete, students are inclined to use media related to the problem given. (3) Deaf students tend to be able to make predictions to obtain a mathematical model of a given problem, but the students are likely to be unable to provide a reason to validate the assumption. (4) if the deaf students can solve the problem, they tend to use a way of counting to solve it.

1 INTRODUCTION

A deaf student is students who have impaired hearing function, either in part or in a whole that has a complex impact on their life. The deaf student generally has normal or average intelligence, but because their intellectual development is strongly influenced by language development, the deaf student will have lower intelligence compared to normal students. This is influenced by the difficulty of understanding the language, so that deaf student in their acquisition of information and language is lack of vocabulary, difficult to understand the expression of language that contains the meaning of metaphor and abstract words and it will result on the following: deaf student needs more time to learn how to connect the relationships between mathematical concepts and to communicate them.

The results of a study conducted by Martin found that deaf student lacked the cognitive potential possessed by normal students to the maximum extent in processing information (Martin, 1991). This causes cognitive skills possessed by a deaf student to be lower than normal students (Barbosa, 2014). Deaf students are less likely to use their cognitive potential to the maximum extent in processing information due to limitations in communication and problem solving (Foisack, 2003), since the deaf student has such a deficiency above causing them to have a lower learning achievement when compared to normal students for ~~materials~~ lessons that are abstract (Somad, 1996). In general, if the deaf student cannot understand the problems presented orally, they will not be able to solve them properly (Carrasumada, 1995).

Although deaf students have the limited listening ability, it does not mean that they cannot participate in learning process activities. Limitations in auditory abilities can be overcome by their visual capabilities. The best mathematical abilities possessed by children who experience visual impairment related to visual (Nunes, 2004). Visual is very useful for the deaf student in building an understanding of a given concept. Thus, hearing impairment possessed by those students is not a direct cause of difficulty in learning mathematics because of not all deaf students have math scores more than normal students; about 15% of deaf students have an average or above average standard test (Wood, 1983). In addition, the results of previous relevant research reports found no correlation or only a very small correlation between hearing impairment levels and mathematical

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achievement. These results indicate that hearing loss is not a direct cause of difficulties in learning mathematics (Wood, 1983 and Nunes, 1998). From the above description, this study examines qualitatively to explore the ability of mathematical connections on aspects of the connection between topics in mathematics. The ability of a mathematical connection is the ability to connect conceptual and procedural knowledge, use mathematics on other topics, use mathematics in everyday life activities, and inter-topic connections in mathematics (Coxford, 1995). In expressing the ability of mathematical connections in hearing impaired students, researchers provide tests in the form of images that are interesting, realistic and close to the environment of everyday students.

2 RESEARCH METHOD

This research is included in qualitative research with case study design. The researcher used a case study design to explore in depth and detail on the subjects to be studied using various procedures to collect data. Data collection techniques used i.e.; provide tests related to the interconnection of topics in mathematics i.e. geometry (calculating extent of a rectangle) and algebra (solving two linear equations) and in-depth interviews on the results of work. The number of subjects in this study was six people who were taken purposively in 3 schools namely; 1 SLB in East Nusa Tenggara (NTT) and 2 SLB in Central Java. The following are the problems given to the research subjects.

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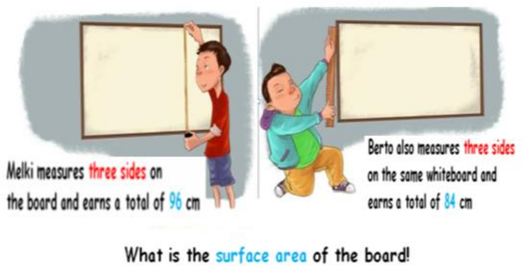

Figure 1.

3 RESULTS

There are several findings obtained by the researcher when subjects completed a connection test related to the interconnection of topics in mathematics. These findings refer to three indicators of interconnection on topics in mathematics (a) determine the same concept representation, (b) determine the mathematical concepts to be used, and (c) use predetermined concepts to solve the problem. The results of the analysis of each indicator are presented as follows;

3.1 Determine the Same Concept Representation

Based on the findings it is known that all subjects (S1, S2, S3, S4, S5 and S6) determine the same concept representation of the problem in terms of equations i.e.; $2p + l = 96$ cm, $p + 2l = 84$ cm, $2p + 1l = 96$ cm, $1p + 2l = 84$ cm, $p + p + l = 96$ cm, $p + l + l = 84$ cm, $p + p + l = 96$, and $p + l + l = 84$. To obtain the equation, each subject works in several ways i.e.;

3.1.1 Make a Picture

S1, S2, S5, and S6 illustrate the problem by creating a rectangular image. From the interview, the subject said that the three possible sides that can be measured from a rectangle are the length, length, width, and length, width, width. S1 uses a finger to cover one side (side 1) on the rectangle so that the visible sides are *p*, *p*, and *l*. Furthermore, s1 closes one side (length/*p*) of the rectangle, so that the visible sides are width *l*, *l*, and *p*. From the activity, s1 wrote in the form of equation $2p + l = 96$ cm and $p + 2l = 84$ cm. S2 makes a rectangular image and writes three sides to the rectangle i.e; *p*, *p*, *l* and write the equation $2p + 1l = 96$. Next, he write *l* on the other side and obtained the equation $1p + 2l = 84$, while s5 and s6 had the same way of obtaining equations in which the representation with the problem given was making 2 images in rectangles. In the first picture, he made an arrow that starts from the length, width, length, and writes the equation $p + p + l = 96$ to show the three sides measured by Melki. In the second picture, it also creates an arrow line starting at the width, length, width and writing the equation $p + l + l = 84$.

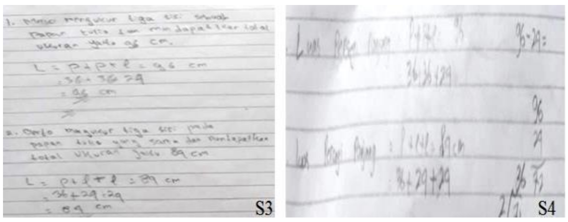

Figure 2: Picture based category.

With respect to three sides each measured, the four subjects had the same opinion that Melki & Berto measured three different sides on the same whiteboard surface. This can be seen from the mathematical sentences written by each subject i.e. $2p + l$, $p + 2l$, $2p + 1l$, $1p + 2l$, $p + p + l$, and $p + l + l$, and it is also seen from the total size which is different obtained by each subject in the form $p + p + l = 96$ and $p + l + l = 84$. In relation to the form of equation obtained S1 i.e. $2p + l = 96$ and $p + 2l = 84$ is different from the equation obtained S2 i.e. $2p + 1l = 96$ and $1p + 2l = 84$. S1 obtains $2p + l$ of $p + p + l$ by adding the same variable, $p + p$, to get $2p$. Likewise with $p + 2l$ from $p + l + l$ and summing the same variable that is l so as to get $l + l = 2l$. This differs from the form of the equations obtained by S2 i.e. $2p + 1l = 96$ and $1p + 2l = 84$. S2 does not multiply constants 1 on l and constant 1 on p. In case, multiplication 1 with any number results in the number itself so that $1l = l$ and $1p = p$. Thus, S2 knowledge of multiplication with number 1 is not applied in the form of $2p + 1l$ and $1p + 2l$, although the form of equation obtained by S2 i.e. $2p + 1l = 96$ and $1p + 2l = 84$ is true but the form of the equation can still be simplified to $2p + l = 96$ and $p + 2l = 84$. Similarly to the form of the equation obtained by S5, the result is the same as that obtained by S6 i.e. $p + p + l = 96$ and $p + l + l = 84$. In the equation $p + p + l = 96$, there are two equal variables p whose sum equals $p + p = 2p$, whereas the equation $p + l + l = 84$ also has two equal variables l and can be summed i.e. $l + l = 2l$. Although the form of equations obtained by S5 and S6 are true, but the equation $p + p + l = 96$ and $p + l + l= 84$ can still be simplified to $2p + l = 96$ and $p + 2l = 84$. The understanding of S5 and S6 relates to summing the two same variables in this case is not used.

3.1.2 Rewrite

In this category, there are two subjects namely S3 and S4 which illustrate the problem by rewriting the problem. According to S3 and S4 that measuring three sides on a whiteboard surface is similar to calculating the surface area of the board. S3 writes in the form $L = p + p + l = 96$ cm and $L = p + l + l = 84$ cm. This is the same as the one written by S4 that is the area of rectangle $= p + p + l = 96$ cm and the area of rectangle $= p + l + l = 84$ cm. This shows that there is a misunderstanding by S3 and S4 on the concept of the area and the circumference of the rectangle.

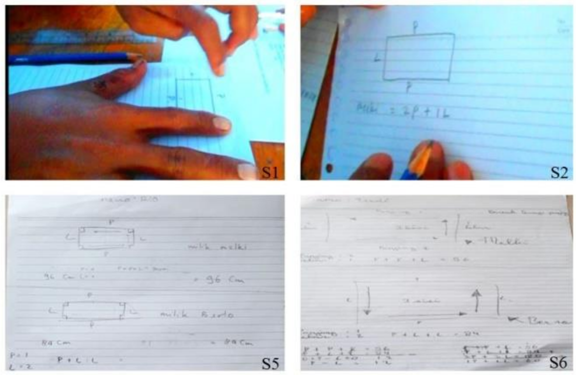

Figure 3: Rewriting Category.

Against the form of equations obtained by S3 and S4, i.e. $p + p + l = 96$ and $p + l + l = 84$ wherein the equation $p + p + l = 96$, there are two equal p variables which can sum up i.e. $p + p = 2p$, whereas in the equation $p + l + l = 84$ there are also two variables l which are the same and can be summed up that is $l + l = 2l$. Although the equations obtained by S3 and S4 are true, the equations $p + p + l = 96$ and $p + l + l = 84$ can still be simplified to $2p + l = 96$ and $p + 2l = 84$. Thus, and S4 corresponds to summing the same two variables in this case which is not used. To obtain a mathematical model, the six subjects made a conjecture by saying that the total size of the three sides as measured by Melki is greater than the total size of the three sides as measured by Berto. The researcher sees that the allegation is built with the argument that the length (p) is larger than the width (l), since $p>l$ then $2p> 2l$ is consequently $2p + l >p + 2l$. From this process, all six subjects suspected that $2p + l = 96$ cm and $p + 2l = 84$ cm. The allegations made by each subject are not supported by mathematically strong arguments based solely on the logical principle and the understanding of each subject that in the rectangular image, the length of the sides is always longer than the width of the sides. The researcher views that there is a misconception of the concept of understanding that the size of the long side is always longer than the size of the width of a rectangle. In fact, the size of the side of a rectangle only expresses a dimension of the two-dimensional figure.

3.2 Determine the Mathematical Concepts That Will be Used

In the indicators determine the mathematical concepts that will be used in connection with the connection between topics in this problem, which the subjects in searching for p and l values are not yet known, the researcher makes in 2 categories namely; counting and guessing.

3.2.1 Counting

S1, S2, S5 and S6 use numerical methods (counting one by one), adding up, and substituting to find the value of p and l;

a Summing Up

The four subjects summed the equation $2p + l = 96$ with the equation $p + 2l = 84$. They add up the same variables i.e $2p + p = 3p$ and $l + 2l = 3l$, but there are differences in the way S5 and S6 do; S6 creates a line and S5 creates a circle-shaped curve to group the same variables and calculates the number of variables. S5 and S6 have a creative way of grouping the same variables and counting them. In the end, the four subjects obtained the same result, namely $3p + 3l = 180$.

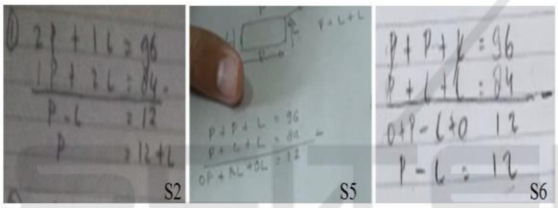

Figure 4: Categories based on how to add (sum up).

Based on Figure 4, it appears that the four subjects simplify the equation $3p + 3l = 180$ by multiplying by1/3. S1, S5 and S6 write in the form of $1p + 1l = 60$. The equations obtained by S1, S5, and S6 are true, but the form of the equations can still be simplified to $p + l = 60$. Figure 4: Categories based on how to add (sum up). Based on Figure 4, it appears that the four subjects simplify the equation $3p + 3l = 180$ by multiplying by 1/3. S1, S5 and S6 write in the form of $1p + 1l = 60$. The equations obtained by S1, S5, and S6 are true, but the form of the equations can still be simplified to $p + l = 60$.

b Substitution

The second step taken by the S1 to obtain the length and width of the rectangle is a substitution. From the equation obtained, $p + l = 60$, written to $1p = 60 - 1l$. The researcher sees that what is written by S1 is true because equation $1p = 60\text{-}1l$ if simplified will be $p = 60 - l$ is a form of equation equivalent to the equation $p + l = 60$.

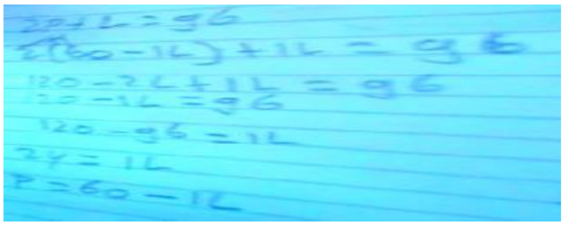

Figure 5: Substitution by S1.

According to Fig. 5, S1 obtains $l = 24$, subsequently subordinates the value of $l = 24$ to the equation $p = 60\text{-}l$ and obtains a value $p = 36$

c Subtractions

The second step carried out by the subjects S2, S5 and S6 are to reduce the equation $2p+l = 96$ with the equation $p+2l = 84$. The three subjects performed a reduction operation as usual. They subtract the same variables i.e. $2p\text{-}p = 1p$ and $l\text{-}2l = \text{-}1l$. However, there is a difference in the way S6 makes it that it creates a line to cross out two variables p and 2 variable l (make it 0). In the end, S2, S5 and S6 get the same result, $p\text{-}l = 12$

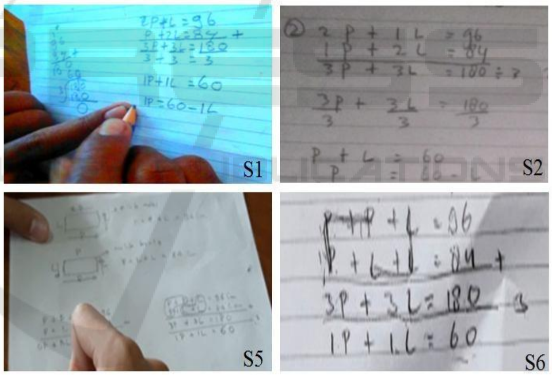

Figure 6: Categories based on reduction method.

According to Figure 6, the three subjects obtained $p\text{-}l=12$, and wrote $p = 12+l$. The researcher sees what the three subjects are writing is true because the equation $p=12+l$ is equation equivalent to the equation $p\text{-}l=12$. In Figure 7, the three subjects have different ways of obtaining p and l values. S2 obtains the equation $p = 60 - l$ and $p = 12 + 1$, so that it is solved by writing together $60 - l = 12 +l$. The interview result obtained that S2 wrote thus because "equally p". Next, form $60 - l = 12 + l$ it completes and obtains $l = 24$. From that result it is substituted to the equation $p + l = 60$ and obtains the value $p = 36$. S5 sums the equation $p + l = 60$ with $p - 12$, to obtain $p = 36$. To obtain the value of l, S5 substitutes the value $p = 36$ to the equation $p + l = 60$, and obtains l

= 24. While S6 subtracts the equation $p + l = 60$ with $p - l = 12$, and the result obtained is $l = 24$. To obtain a p-value, he substitutes the value of $l = 24$ in the equation $p + l = 60$, thus obtaining $p = 36$

Figure 7: Solve the problem with subtraction.

From the way of S1, S2, S5, and S6, the researcher sees that the concept of finding the value of *p* in *l* is the same, but there are differences in the procedure. The difference in procedure shows the creative thinking of each subject in solving problems.

3.2.2 Guessing

There are 2 subjects i.e. S3 and S4 have different ways of finding *p* and *l* values. S3 writes in the form of the equation $L = p + p + l = 96$ cm and $L = p + l + l = 84$ cm and makes a guess by taking the value $p = 36$, $l = 24$. In Figure 8 below, shows that S3 replaces the value of $p = 36$, $l = 24$ to equation $2p + l = 96$ and equation $p + 2l = 84$ so that the equation becomes true (the value on the right-hand side is the same as the value on the left-hand segment. From the interviews, it is obtained that S3 takes p-value $= 36$, $l = 24$ by "guessing." Although "guessing" is one of the strategies for solving problems, it needs mathematical argumentation to strengthen the validation of the alleged/guessed evidence. While S4 has a different way with S3. S4 adds the equation $2p + l = 96$ with the equation $p + 2l = 84$. From the sum, he got the value on the right-hand side which is 180, then he calculated $180 \div 3 = 60$. From the results obtained, then he calculated $96 - 60 = 36$, and he obtains a value of $p = 36$. The process performed by S4 in making mathematically incorrect allegations. Next, to obtain a value of *l*, S4 subtracts the equation $2p + l = 96$ with the equation $p + 2l = 84$. The result obtained in the process is $l = 24$.

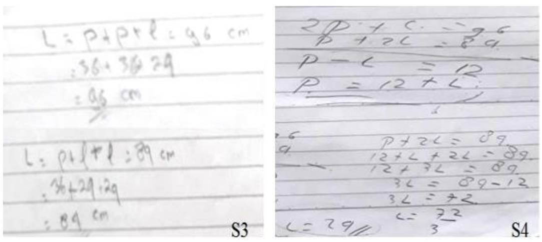

Figure 8: Guessing based category.

From the process carried out by S3 and S4 in Figure 8, the researcher saw that the two subjects did not have an initial plan to find the length and width on the surface of the blackboard. However, both subjects have good ability to make guesses even though they cannot provide mathematical arguments to strengthen the validation of such alleged evidence

3.3 Use Predefined Concepts to Resolve the Issue

From the result of the work and the interview result, it was found that all subjects knew that the formula for the area of the rectangle is $p \times l$. From the results obtained, where $p = 36$ and $l = 24$, the six subjects substitute into the formula and obtain the area of the rectangle. From the results of the work, S1 and S2 obtained 864 cm2, S3 obtained 864 cm, S4, S5, and S6 obtained 864. From the calculation of 36×24, all subjects who answered correctly that 864. S3, S4, S5, and S6 did not know by both that the unit area of the rectangle is centimeter squared (cm^2).

4 DISCUSSION

In building an understanding of the problem, there is a tendency that deaf students illustrate the problem in the form of images. Illustrating the problem in the form of images shows that the thought process constructed by the subject starts from the semi-concrete to the abstract. Deaf students find it easier to understand the problem if the problem presented in Visual form is very beneficial for a deaf student (Frostad, 1999). In addition, illustrating in the form of images is the best mathematical ability possessed by deaf students (Nunes, 2004). To solve the given problem, there are two categories of ways done by the six subjects to say and guess.

Summing up is counting one by one. Deaf student performs oral calculations and written calculations using sign language which is a simple arithmetic skill possessed by a deaf student (Merrienboer, 2005). Limitations do not become an obstacle to the six subjects in doing the exploits through images, doing algebraic engineering by summing and subtracting the equations that have been obtained. The way in which the subjects are used is not one of the methods taught in solving the two-variable linear equation system. This way arises as a result of the creative thinking by the subject and also because of the knowledge that has been stored in the form of a schema in long-term memory, not from its ability to engage itself with unorganized information elements in long-term memory (Nunes, 2002).

Thus, hearing loss possessed by those students is not a direct cause of difficulties in learning mathematics. Deaf students have elaborated the linking of existing information on the problem with the knowledge that has been formed to obtain ideas and communicate them through images and writing them to solve the problems given.

5 CONCLUSIONS

Based on the result of mathematical connection ability analysis to deaf students in completing tests related to the connection between mathematics topics concluded that deaf students can solve non-routine problems with high difficulty level visualized in the form of images by following the steps of problem-solving according to Polya.

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