DEAF STUDENT AND MENTAL ACT IN MATHEMATICS PROBLEM SOLVING

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Abstract: Mathematics has an important role in the cognitive development of deaf students. Through learning mathematics in schools, deaf students will explore and build knowledge, because literally mathematics is the parent of knowledge and human activities. One important aspect in learning mathematics is the ability to solve problems. Problem solving means engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings.This study aims to analyze the mental act of deaf students in solving mathematical problems in fraction material. Respondents of 20 students were randomly selected from 3 special schools. This type of research is qualitative with a case study design. Data was collected through the instrument of problem solving abilities, interviews, and observations. Data were analyzed using grouded theory. The results of this study indicate that the mental act used by deaf students in solving mathematical problems is interpreting, explaining, inferring, and problem solving.

Keywords: deaf student; mathematics; mental act.

1. INTRODUCTION

Mathematics has an important role in the cognitive development of deaf students (Arnol, 1996). Through learning mathematics in schools, deaf students will explore and build knowledge (NCTM, 2000). Because literally mathematics is the parent of knowledge and human activities (Fennema and A. Romberg, 1999). One important aspect in learning mathematics is the ability to solve problems (NCTM, 2000). Problem solving means engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. By learning problem solving in mathematics, students should acquire ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations that will serve them well outside the mathematics classroom*"* (NCTM, 2000). But in fact, based on preliminary research conducted on deaf students in Bogor, West Java, Indonesia, in three special schools it was found that 80% of deaf students stated that mathematics was a difficult subject to understand and the results of interviews with teachers showed that there was very little opportunity for deaf students in learning mathematics if the learning approach used is still conventional and not in accordance with the characteristics of deaf students. Bogor is one of the major cities in Indonesia. There are 10 special schools for deaf students in the city of Bogor (Kemendikbud,

2017). Therefore, the three schools observed were considered to be representative to illustrate how the learning conditions of mathematics for deaf students in Indonesia.

Basically, experts have stated that deaf students have visual potential that is very important to be used in learning mathematics (Luckner, Bowen and Carter, 2001). Through this visual potential, mathematics teachers in special schools should strive to facilitate learning approaches that are in accordance with the potential of deaf students (Pagliaro, 1998); (Pagliaro and Kritzer, 2013). But in fact, there are still teachers for deaf students in Indonesia who ignore the visual potential of deaf students in designing, implementing, and developing mathematics learning.

Each student has special characteristics in solving mathematical problems. Methods or approaches to problem solving also vary. (Harel, 2008) explains that mathematical problem solving activities are closely related to students' mental actions. In general, there are four types of mental actions namely interpreting, explaining, problem solving, and inferring. Furthermore, Harel explained that mental act interpretation is a mental activity that is demonstrated by the ability to explain the meaning of information, words, or actions. Meanwhile, mental act explaining means making ideas, situations, or problems clear, by describing them in more detail or by expressing relevant facts or ideas. Whereas mental act problem solving means the process of finding solutions to difficult problems. Mental act inferring is inferring (information) from evidence and reasoning, not from explicit statements.

Deaf students are Visual-Spatial learners (Dowaliby & Lang, 1999; (Hauser, Lukomski, & Hillman, 2008); (Marschark & Hauser, 2012). Therefore in learning mathematics it is very important to use visual displays to support Deaf students in their ability to solve mathematical problems Based on the theory that deaf students are visual learners, it is very important to examine how the relationship between mental deaf students' mentality in solving mathematical problems and visual abilities of deaf students in learning mathematics. Very important as information material so that there is a change in the approach to learning mathematics for deaf students in special schools in Indonesia.

2. METHODS

The approach used in this study is a qualitative approach (Creswell, 2012). deaf in completing Fractional problems in SLB (special school). This research was conducted in three special schools in Bogor, West Java, Indonesia. The three schools are (1) SLB Fitria; (2) SLB Tunas Kasih; and (3) SLB Dharma Wanita. A total of 20 class 7 deaf students were used as respondents. Deaf students were given research instruments then the results of student answers were analyzed using Harel's theory (Harel, 2008). Data collection techniques using the Test Instrument, Observation, and Interview. Data were analyzed to develop the mental act theory of deaf students using coding and constant comparison techniques (Gall and Borg, 2003).

3. RESULTS AND DISCUSSION

Results

Mental acts found in deaf students are interpreting, explaining, problem solving, and inferring.

3.1. Mental Act Interpreting

Mental act Interpreting is mental activity that is demonstrated by ability explain the meaning of

information, words, or actions (Harel, 2008). Based on data analysis, mental *Interpreting* deaf students'students were found as follows.

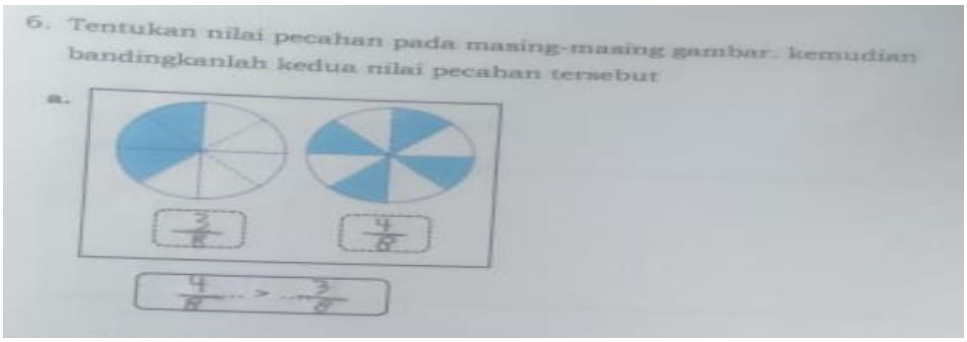

Figure 1 The first example of mental act interpreting from deaf students' answers.

Figure 1 shows that deaf students solve mathematical problems by means of mental act interpreting. In this case, the deaf student is asked to "write the fraction shape on the problem and compare the fraction values of the two pictures". From the answers given, it appears that deaf students understand the problem and solve it using mental act interpreting through the interpretation of the value of an image or symbol representation. The solution to the problem given is "the first picture shows the fraction form 3/8 while the second picture (picture) shows the fraction 4/8 and 4/8> 3/8". Researchers assess this answer as mental act interpreting. Another example of mental act interpreting from deaf students' answers is as follows.

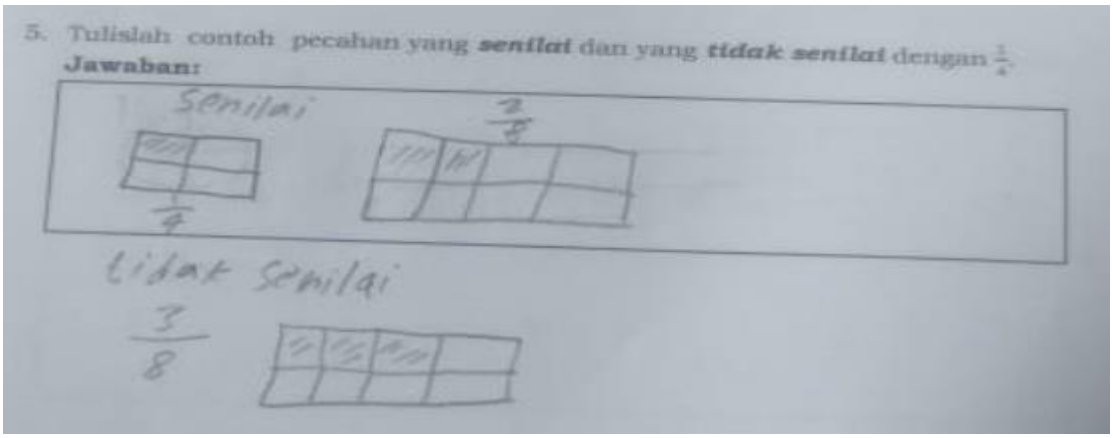

Figure 2 The second example of mental act interpreting from deaf students' answers.

Figure 2 shows that deaf students solve mathematical problems by means of mental act interpreting. In this case, deaf students are asked to "write examples of fractions that are worth and not worth $\frac{1}{4}$". From the answers given, it appears that deaf students understand the problem and solve it using mental act interpreting through the interpretation and representation of images. The solution to the problem given is "fractional form which is equal to $\frac{1}{4}$ is $\frac{2}{8}$and which is not equal to $\frac{1}{4}$ is $\frac{3}{8}$. Researchers assess this answer as mental act interpreting.

3.2. Mental Act Explaining

Mental act explaining is a form of human reasoning. Literally mental act explaining means making an idea, situation, or problem clear, by describing it in more detail or by disclosing relevant facts or ideas (Harel, 2008). Based on data analysis, mental deaf students' mental explaining was found as follows.

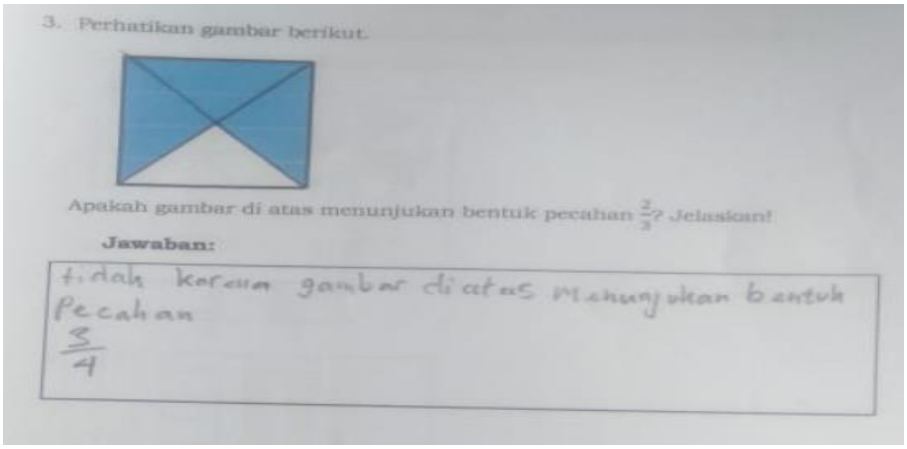

Figure 3 The first example of mental act explaining from deaf students' answers.

Figure 3 shows that deaf students solve mathematical problems by means of mental act explaining. In this case, the deaf student is asked to "explain whether the picture in the problem shows the fraction of $\frac{2}{3}$ ". From the answers given, it appears that deaf students understand the problem and solve it using mental act explaining through symbol representations and explanations. The student's explanation is "No. Because the picture shows the shape of the fraction $\frac{3}{4}$ ". Researchers assess this answer as mental act explaining. Another example of mental act explaining from deaf students' answers is as follows.

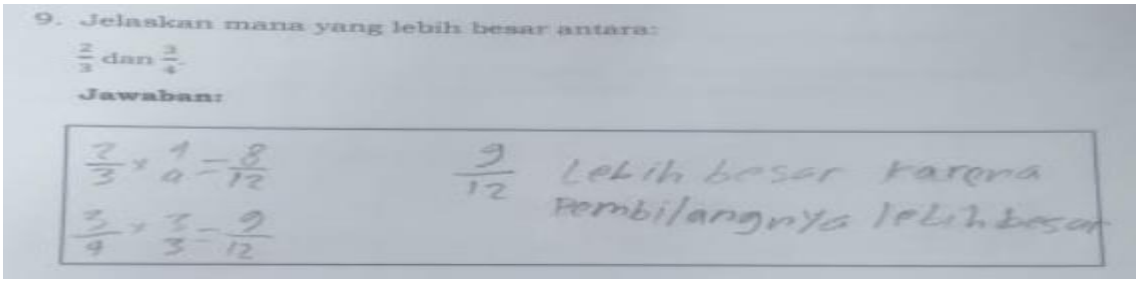

Figure 4 The second example of mental act explaining from deaf students' answers.

Figure 4 shows that deaf students solve mathematical problems by means of mental act explaining. In this case, deaf students are asked to "explain which is greater between $\frac{2}{3}$ and $\frac{3}{4}$ ". From the answers given, it appears that deaf students understand the problem and solve it using mental act explaining through arithmetic manipulation in the form of fractions accompanied by an explanation. The first step carried out by deaf students in solving the problem is to "equate the denominator of $\frac{2}{3}$

and $\frac{3}{4}$ ie" $\frac{2}{3} = \frac{2}{3} x \frac{4}{4} = \frac{8}{12}$ and " $\frac{3}{4} = \frac{3}{4} x \frac{3}{3} = \frac{9}{12}$" then explains that" $\frac{2}{3}$ or $\frac{9}{12}$ is bigger because the numerator is bigger". Based on interviews conducted with these students it was found that the deaf students compared numbers 9 and and 8 which were numerators of $\frac{8}{12}$ and $\frac{9}{12}$ which were relevant to $\frac{2}{3}$ and $\frac{3}{4}$. Researchers assess this answer as mental act explaining. Another example of mental act explaining from the next deaf student's answers is as follows.

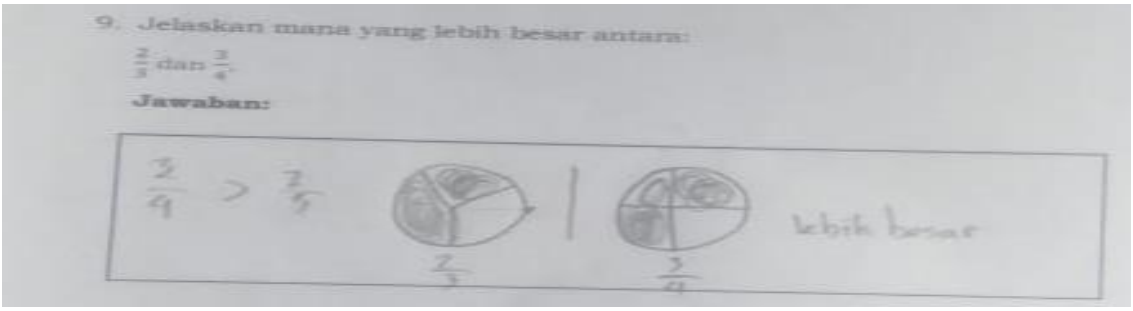

Figure 5 The third example of mental act explaining from deaf students' answers.

Figure 5 shows that deaf students solve mathematical problems by means of mental act explaining. In this case, deaf students are asked to "explain which is greater between $\frac{2}{3}$ and $\frac{3}{4}$". From the answers given, it appears that deaf students understand the problem and solve it using mental act explaining through the representation of images and explanations. The first step carried out by deaf students in solving the problem is to represent $\frac{2}{3}$ and $\frac{3}{4}$ then mention that "picture $\frac{3}{4}$ is bigger". Researchers assess this answer as mental act explaining. There are different approaches to thinking shown by deaf students based on Figures 2 and 3. In the picture 2 thinking approaches that are used to solve problems are through arithmetic manipulation while in Figure 3 through image representation. This shows that there are variations in the mathematical thinking approach in an act of mental explaining by deaf students.

3.3. Mental Act Problem Solving

Mental act problem solving is a mental activity in the process of finding solutions to difficult problems (Harel, 2008). Based on data analysis, mental deaf students' mental problem solving was found using three different approaches. The approach is the mental act problem solving approach to image representation, arithmetic, and coding. Following are the findings of each of the mental act problem solving approaches in deaf students.

3.3.1 Mental Act problem solving through Image Representation Approach

One of the mental act problem solving through image representation approaches found in deaf students is in the following picture.

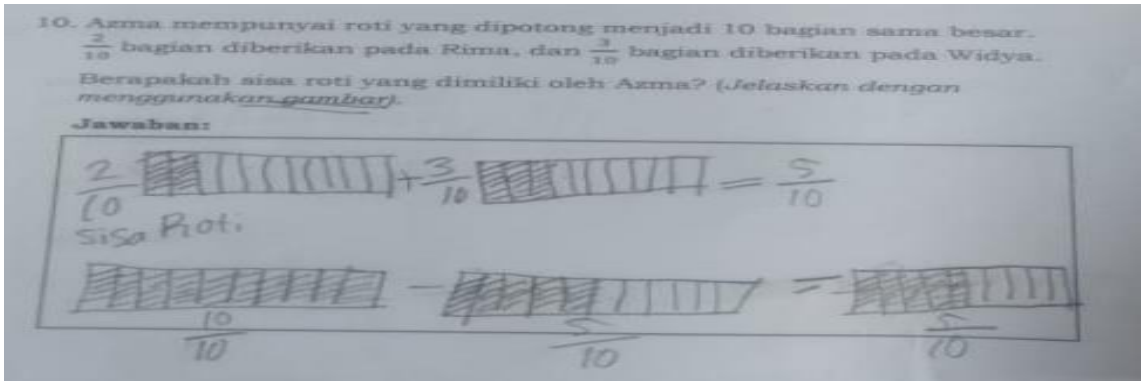

Figure 6 Examples of mental act *problem solving with the image representation approach of answers* deaf students'.

Figure 6 shows that deaf students solve mathematical problems by means of mental act problem solving through the image representation approach. In this case, the deaf student is asked to solve the problem namely "Azma has 10 pieces of bread that is cut equally. $\frac{2}{10}$ part was given to Rima, and $\frac{3}{10}$ part was given to Widya. How much bread does Azma have? ". From the answers given, it appears that deaf students understand the problem and solve it with mental act problem solving through the image representation approach and a little explanation. Stages of students' answers are "stage 1: adding bread distributed to each child through pictures and mathematical symbols $\frac{2}{10} + \frac{3}{10} = \frac{5}{10}$. Next, stage 2: deaf students see the remaining bread distributed as a difference between $\frac{10}{10} - \frac{5}{10} = \frac{5}{10}$". Researchers assess this answer as mental act problem solving through the image representation approach.

3.3.2 Mental Act problem solving through the Arithmetic Approach

One mental act problem solving through the arithmetic approach found in deaf students is in the following figure.

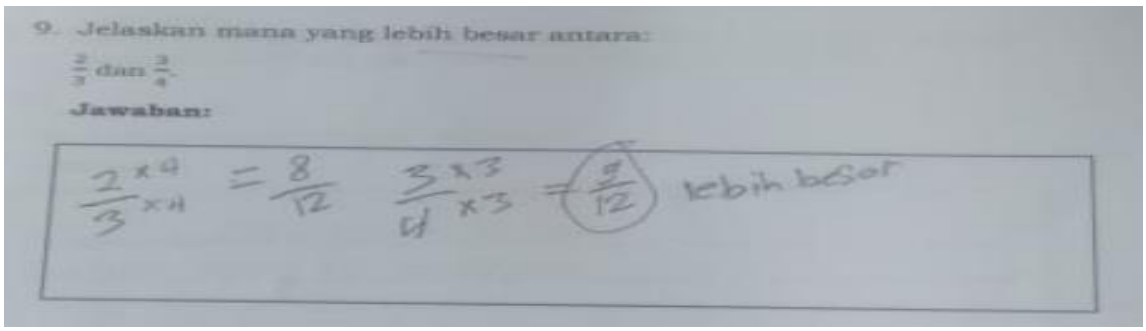

Figure 7 Examples of mental act *problem solving with an arithmetic approach from the answers* of deaf students.

Figure 7 shows that deaf students solve mathematical problems by means of mental act problem solving through an arithmetic approach. In this case, deaf students are asked to solve the problem that is "determine which is greater between $\frac{2}{3}$ and $\frac{3}{4}$". From the answers given, it appears that deaf students

understand the problem and solve it with mental act problem solving through an arithmetic approach. From interviews conducted it was found that the way of thinking with mental act problem solving through the arithmetic approach namely: "stage 1: deaf students make mathematical equations to equate the denominator of the two fractions namely $\frac{2}{3} x \frac{4}{4} = \frac{8}{12}$ and $\frac{3}{4} x \frac{3}{3} = \frac{9}{12}$ ¾ x 3/3 = 9/12. Next, Phase 2: Deaf students compare numbers on the numerators from $\frac{8}{12}$ and $\frac{9}{12}$. Then, Stage 3: concludes that $\frac{9}{12}$ is greater than $\frac{8}{12}$ because 9 is greater than 8 ". Researchers assess this answer as mental act problem solving through an arithmetic approach.

3.3.3 Mental Act of problem solving through approach Coding

One act of mental problem solving approach to coding found on the deaf students in the following figure.

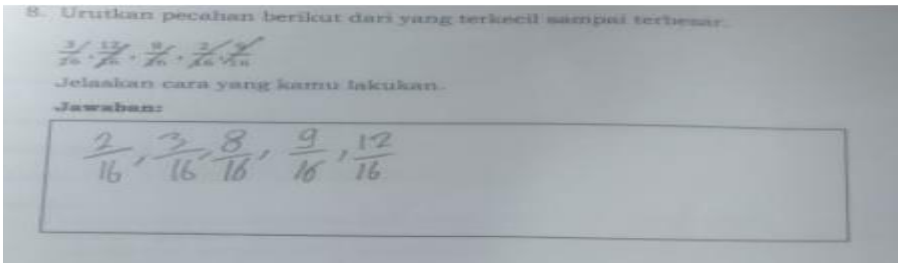

Figure 8 Example of a mental act problem solving approach to drawing from the answers of deaf students

Figure 8 shows that deaf students solve mathematical problems by means of a mental act problem solving through the coding approach. In this case, deaf students were asked to solve the problem of "sort fractions $\frac{3}{16}, \frac{12}{16}, \frac{8}{16}, \frac{2}{16}, and \frac{9}{16}$ from the smallest to the largest". From the answers given, it appears that deaf students understand the problem and solve it with mental act problem solving through the coding approach. Based on the analysis of students' answers, deaf students use coding "/" (slash) as a symbol that can help them in doing the sequence of fractions (smaller to larger). Researchers assess this answer as a mental act problem solving through the coding approach.

3.4. Mental Act Inferring

Mental act inferring is a mental activity in concluding (information) from evidence and reasoning, not from explicit statements (Harel, 2008). Based on the data analysis, found mental act inferring deaf students as follows.

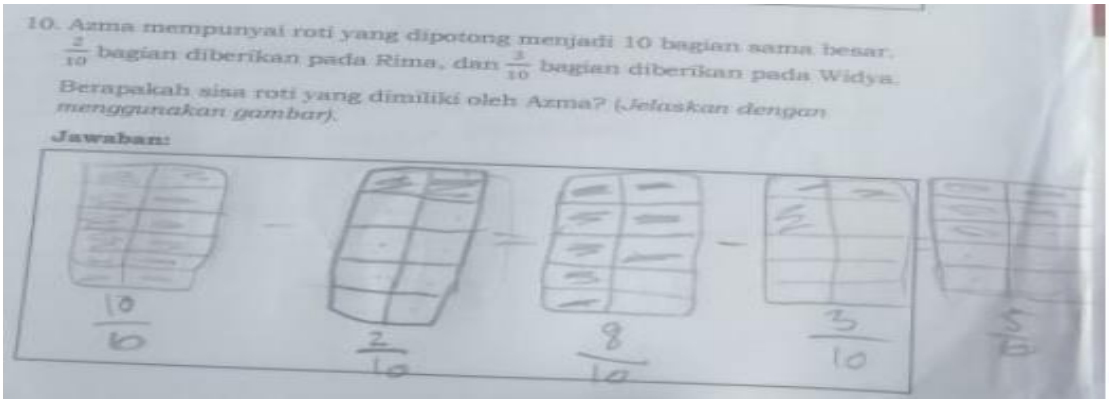

Figure 9 The first example of mental act *inferring from the answers* of deaf students

Figure 9 shows that deaf students solve mathematical problems by means of mental act inferring. In this case, the deaf student was asked to solve the problem namely "Azma has 10 pieces of bread that is cut equally. $\frac{2}{10}$ part was given to Rima, and $\frac{3}{10}$ part was given to Widya. What is the remaining bread owned by Azma? " From the answers given, it appears that deaf students understand the problem and solve it using mental act inferring through pictures and symbols without being accompanied by statements in the form of words. Based on the results of interviews conducted, deaf students try to reason based on the information available on the problem (problem). Forms of reasoning that are done include symbolizing the whole bread as a part $\frac{10}{10}$. Then subtract it with $\frac{2}{10}$ and $\frac{3}{10}$. So we get $\frac{5}{10}$of the remaining bread. Researchers assess this answer as a mental act inferring. Another example of the mental act inferring from the answers of deaf students is as follows.

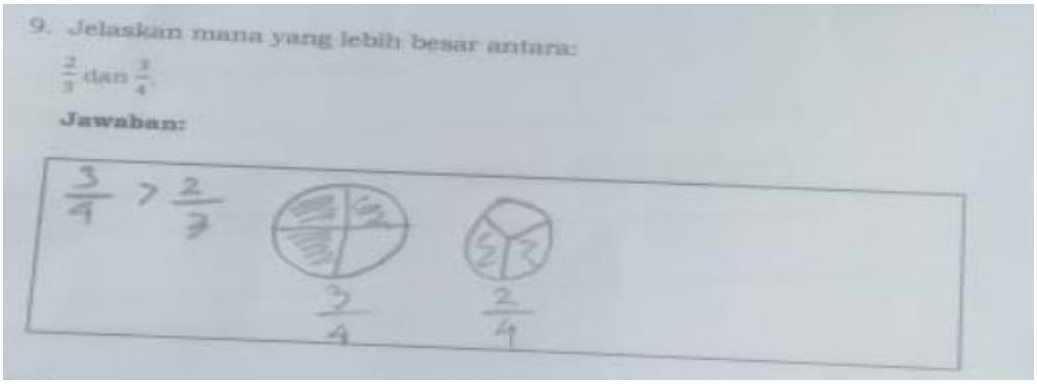

Figure 10 The second example of mental act *inferring fromanswers* deaf students'.

Figure 10 shows that deaf students solve mathematical problems by means of mental act inferring. In this case, deaf students are asked to "explain which is greater between $\frac{2}{3}$ and $\frac{3}{4}$. From the answers given, it appears that deaf students understand the problem and solve it using mental act inferring through pictures without explanation. Deaf students in this case just simply describe the form $\frac{3}{4}$ and $\frac{2}{3}$ then conclude that $\frac{3}{4} > \frac{2}{3}$".

A summary of the distribution of mental actions of deaf students in solving mathematical problems in table 1 below.

Table 1 Distribution of mental acts of deaf students in solving mathematical problems

No.	Mental Act	Respondents		Number of
		Men	Women	
1.	Interpreting	5	7	12
2.	Explaining	6	8	14
3.	problem solving	8	12	16
4.	Inferring	9	4	13
Respondents = 20 Students				

Based on table 1 obtained information that many male students who use mental act interpreting in solving fewer problems compared to female students. So it is with mental act explaining and problem solving. But male students are more dominant in mental acting than girls. In addition it can also be informed that of the 20 respondents, it was found that overall 12 deaf students solved the problem using mental act interpreting, 14 students used mental act explaining, 16 students used mental act problem solving, and 13 students used mental act inferring.

The findings of this study are in line with research conducted by Harel (2008) which revealed that in general there are four mental actions of students in solving mathematical problems namely explaining, interpreting, problem solving, and inferring. The difference, the subject of research conducted by Harel is on "normal students" while our research on deaf students.

Discussion

There are several factors that have the potential to be the cause of the mental act formation process of deaf students. First, in practice mathematics learning for deaf students who use the EL-CPA learning model is learning that combines direct learning experience and translational representation in the form of Concrete - Pictorial (picture) - Abstract. One form of learning experience that is done by deaf students in the EL-CPA model is a mathematical exploration of manipulative models of various forms of fractions and visual fraction operations. In this activity, deaf students explore and gain their knowledge through activities that involve hands-on & minds-on activity. The hands-on & minds-on activities contained in the forerunner of the EL-CPA model make deaf students have in-depth knowledge and understanding of the material and the formation of mental act psychologically. This finding is relevant to the results of research conducted by Witzel (2005) who found that hands-on & minds-on activity activities are able to form students' mental actions towards learning mathematics & science.

The second factor that is considered to be a potential cause of the formation of mental deaf students is because in the application of the EL-CPA learning model involves a Concrete - Pictorial - Abstract (CPA) approach. Leong, & Cheng (2015) explain that the Concrete - Pictorial - Abstract (CPA) Approach is a learning approach that gives students the learning experience and meaningful context that is needed, using concrete manipulative objects and image representation to build more abstract mathematical knowledge. This is in line with what was expressed by Maccini et al, (2007) which states that the Concrete-Representational-Abstract approach is a learning approach that helps students connect concrete objects to abstract shapes that aim to build students' understanding of mathematical concepts and processes, and mental actions in solving problems. In addition, the application of the EL-CPA model for deaf students in the CPA approach is applied in the form of concrete - pictorial - abstract representation and vice versa. Practically, in this activity the deaf student manipulates the fraction model concretely through visual aids. Then represent it in the form of images

and mathematical symbols. Understanding the concept of fractional material is formed when deaf students are able to translate the representation. This finding is in line with previous research showing that the CPA approach is effective for mathematics learning of students with special needs (disabilities) including deaf students, in fractions material from Marschark, M., & Everhart, V. (1999); Van Der Heyden & Witt (2005).

4. CONCLUSION

There are four mental actions of deaf students in solving mathematical problems (problem solving in mathematics). Namely explaining, interpreting, problem solving, and inferring. Meanwhile, the way of thinking approach that tends to be used by deaf students in mental act problem solving is the approach of image representation, arithmetic, and coding. The results of this study can have an impact on the anticipation of the preparation of mathematics teachers in special schools in implementing mathematics learning. it is necessary to understand the mental types of deaf students in preparing the teaching material.

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