Mathematical connection ability of deaf student in completing social arithmetic tests

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Abstract. This study aimed at exploring the mathematical connection ability of grade 8 deaf students in completing the social arithmetic test. This was a qualitative research with case study and grounded theory design. The data were collected by test, interview, observation, and questionnaire. Subjects of the study were six students who were purposively chosen based on the characteristic of language and speech, intelligence, and social emotion and were taken from three different schools, namely: SMPLB Karya Murni Ruteng - NTT, SMPLBN Semarang and SMPLB Don Bosco Wonosobo. The result of work and interview analysis showed that mathematical connection abilities of deaf students in completing social arithmetic test are as follows; (1) in understanding the problem, the deaf students tended to represent the problem by creating a mathematical model, statement, and concrete objects. (2) in making the initial plan to complete the problem, the deaf students tended to use media associated with a given problem. (3) If deaf students could solve the problem, they tended to resolve it by enumerating, substitution, and tinkering with concrete objects.

1. Introduction

Mathematical connection ability is one of the essential capabilities that middle school students either normal or deaf ones should possess. Mathematical connection abilities stated in school mathematics learning objective are; comprehending mathematical concepts, explaining the linkage between concepts and applying the concepts or logarithm flexibly, efficiently, accurately in solving a problem [1]. Deaf students are students who experience hearing loss both partially and completely which have a complex impact on their lives. The limitation possessed by deaf students in terms of obtaining information and understanding language cause them not be able to use their cognitive potency to the maximum extent in processing information [2]. Consequently, the mathematical cognitive skill possessed by deaf students is lower than normal students [3], and lower learning achievement in understanding abstract subjects [4].

In spite of hearing problems, deaf students are still able to learn mathematics. The visual ability can overcome their hearing problems. They can learn mathematics using a visual ability and read lips. The strength possessed by deaf students in the mathematical ability in the field of space and measurement using spatial-visual skills [5] [6]. Besides visual, deaf students also have simple arithmetic skills in performing an oral calculation using sign language [7]. By utilizing the best visual abilities and simple
arithmetic skills they have, researchers would like to explore the mathematical connection abilities possessed by deaf students by giving social arithmetic tests.

2. Methods
This research is included in qualitative research with case study design and grounded theory. 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 [8]. The data were collected by test, interview, observation, and questionnaire from six students who came from three schools. They are SLB B Karya Murni Ruteng - NTT, SMPLB Negeri Semarang, and SLB B Don Bosco Wonosobo. The subjects were taken purposively on the basis of language and speech characteristics, intelligence, and social emotion. Data collection techniques used were giving tests related to social arithmetic problems as well as in-depth interviews with work results. The following problems were given to the research subjects. Mr. Satyo weighs a few fruits until balanced.

3. Results and Discussion
There were some findings obtained by the researcher when the subjects completed the connection tests related to a social arithmetic problem. These findings refer to three indicators, namely (1) compile a mathematical model of the problem given (2) use a mathematical idea to solve a problem given (3) explain the results of problems that are solved by verbal mathematical models or representations. The results of the analysis of each indicator are presented as follows;

3.1. Compile a mathematical model of the problem given
Based on the results obtained, that each subject has a different way to determine a mathematical model. S1 illustrated problems in the form of pictures. S2, S3, and S5 illustrated the problem by writing in the form of words. While the S4 and S6 illustrated the problem using concrete objects. From the 6 subjects, there were 2 subjects namely S1 and S2 who could write mathematical models of a given problem.

Figure 1. The problem was given to the subjects.

Figure 2. Mathematical model by S1 and S2.
Figure 1 shows that S1 communicated ideas by making the picture. He imagined something did not appear to create images of watermelon, bananas, apples and orange to find three mathematical models, namely; \(1S = 1P + 2A\), \(1S + 1A = 1P + 1J\), and \(1P = 1J + 1A\). While S2 communicated ideas by writing a statement to find a mathematical model. He did not use the media, because he was able to think about abstract things.

![Figure 3](image1.png)

**Figure 3.** Mathematical model by S3 and S5.

Figure 2 shows both subjects wrote 1 watermelon is balanced with 1 bunch of bananas and two apples, 1 watermelon, and 1 Apple are balanced with 1 bunch of bananas and 1 orange, and, 1 bunch of bananas balanced with 1 orange and 1 Apple. Although both subjects could state the problem in other forms (statement) but they could not determine the mathematical model of the given problem.

![Figure 4](image2.png)

**Figure 4.** Mathematical model by S4 and S6.

In Figure 3, S4 and S6 illustrated the problem using concrete objects. From the interview, it is known that S4 and S6 found it easier to understand the problem when it was illustrated using concrete objects. Both subjects used concrete objects in the classroom as a media that bridges between the concrete objects (watermelon, bananas, apples, and oranges) and abstract ones (mathematical models). S4 used a paint can as watermelon, a match as a banana, a marker as an Apple and balm as an orange. While S6 used toy car as watermelon, chalk as apple, eraser as orange and a box as 1 bunch of bananas. Although both subjects could understand the issues by stating the problems in other forms (using concrete objects) but they were not able to devise mathematical models of a given problem.

3.2. *Use a mathematical idea to solve a problem given*

Based on the work and interview result against the results of the work done by the six students, there are three categories of procedures to solve the problems, namely substitution, enumerating, and using concrete objects.

3.2.1. *Substitution.* For 6 subjects, there were two, S1 and S2, using substitution to get the number of apples in order to be balanced with watermelon. Both subjects did exploration, i.e. associate equations that have been obtained on the problem and performed algebraic manipulation to get the number of apples in order to be balanced with a watermelon. Although the idea of math used was the same, i.e. the substitution, but both subjects had different ways to solve the problems. The results can be seen in the following figure:
In Figure 4, S1 had a plan to solve the problem by changing equation 1P = 1J + 1A to 1P - 1A = 1J which was equivalent with 1P = 1J + 1A. He replaced 1J to 1P - 1A on the equation 1S + 1A = 1P + 1J to become 1S + 1A = 1P + 1P - 1A. From this process, he got 1S = 2P - 2A. He did elaboration by relating information he got to the knowledge formed (How to solve equations by substitution method). To obtain the number of apples in order to be balanced with a watermelon, he wrote 1S = 2P - 2A and 1S = 1P + 2A become 2P - 2A = 1P + 2A (the reason was the same “1S”) and got A =. He then replaced 1P to 4 A on the equation 1S = 1P + 2A so he got 1S = 6A. Seeing the steps taken by S1, it showed he could finish the problem based on the plan. However, the algebraic forms such as 1S = 2P - 2A, 1S = 1P + 2A can be simplify to S = P - 2A, S = P + 2A. Completion steps made by S1 showed the thinking process is well structured. He could think of abstract things. However, he still needed a media to bridge abstract knowledge. Figure 4 shows that S2 planned to complete the problem by changing 1 bunch of bananas = 1 apple + 1 orange becomes 1 bunch of bananas - 1 apple = 1 orange on 1 watermelon + 1 apple = 1 bunch of bananas + 1 bananas + 1 orange got 1 watermelon = 2 bunches of bananas = 2 apples. S2 communicated ideas by changing the equation and associated with other equations. To get to the abundance of apples in order to be balanced with one watermelon, S2 used similarity between 1 watermelon = 2 bunches of bananas - 2 apples with 1 watermelon = 1 bunch of bananas + 2 apples. He underlined 1 watermelon and wrote 1 bunch of bananas + 2 apples = bunch of bananas = 2 apples. S2 group the same fruit and got 4 apples = 1 bunch of bananas. He then changed 1 bunch of bananas with 4 apples and got 6 apples. The answer he got showed he managed the information by changing 1 bunch of bananas in figure 4 with 4 apples so one watermelon is balanced with six apples.

3.2.2. Enumerating. S3 and S5 used the same way to resolve the problem by enumerating (counting one by one). Although the idea of mathematics used is the same i.e. enumerating, but the thought process and the steps used by S3 and S5 were different. The result can be seen in the following figure;

In figure 5, S3 had an initial plan to resolve the problem by counting. The interview result showed that he counted the number of apples and watermelon in each picture. He counted the number of apples and watermelon on the first picture and wrote 4 + 2 = 6. He then counted the number of apples and watermelon in the second picture and wrote 3 + 1 = 4. For the third picture, he counted the number of apples, watermelon and wrote 4 + 2 = 6. To get the number of apples to be balanced with one watermelon, he took the addition result and wrote 4 + 6 = 10. According to S3, there should be 10 apples to make a balance with one watermelon. While, S5 counted 2 apples and 1 watermelon in the first
picture, 1 apple and 1 watermelon in the second picture and 1 apple in the third picture. To get the number of apples to balance with one watermelon, he added the apples that are 4 and watermelon, that is 2 so he wrote 4 + 2 = 6. According to S5, there should be 6 apples to be balanced with one watermelon. From the process and steps are done by S3 and S5, it can be seen that the two subjects have not understood the problem well. S3 and S5 did not elaborate by associating new information with prior knowledge. However, S3 and S5 have managed the information and communicated the ideas by counting and adding the number of apples and watermelon on the picture. Despite the plan done by S3 and S5, they did not produce a correct answer for the problem given. It is because they misunderstood the problem. The two subjects could not understand the information in each picture where they were connected with one another. Their prior knowledge could be used to resolve the problem.

3.2.3. Using concrete objects. S4 and S6 used the same ideas to complete the problem using concrete objects around them. Even though the mathematical ideas used were the same using concrete objects, but the process and steps used by the subjects were different. The process can be seen in the following figure.

![Figure 7. Category of using concrete objects.](image)

Based on the interview result from S4, it is known that he had an initial plan to resolve the problem by seeing the second picture as a starter point. He balanced the paint can and 1 boardmarker with matchbox and balm (watermelon and 1 apple were balanced with 1 bunch of bananas and 1 orange). He changed 1 balm with 3 board markers which 1 orange is balanced with 3 apples. He then got 1 bunch of bananas balanced with 4 apples. The process showed that he elaborated and associated information in the picture and communicate the ideas using concrete objects so he got 1 bunch of bananas is balanced to 4 apples. To make the number of apples balanced with 1 watermelon, S4 saw the first picture and made 1 paint can balance with 1 matchbox and two board markers (1 watermelon is balanced with 1 bunch of bananas and 2 apples). S4 changed 1 matchbox with 4 board marks (1 bunch of bananas is the same as 4 apples). The result was one paint can is balanced with 6 board markers (watermelon is balanced with 6 apples).

Likewise, S6 who used concrete objects around him such as toy car as watermelon, chalk as apple, eraser as orange, and a box as 1 bunch of bananas. The interview result showed S6 had initial to resolve the problem by seeing the first picture as a starter point. S6 balanced the toy car with the box and 2 chalks (watermelon is with 1 bunch of bananas and two apples). He then added one chalk beside the toy car and one chalk beside the box. He replaced 3 chalks with one eraser (eraser is balanced with 3 chalks or 1 orange is balanced with 3 apples). After seeing the third picture, he replaced the eraser with 3 chalks and found that box is balanced with 4 chalks or 1 bunch of bananas is balanced with 4 apples. S6 used the first picture by making the toy car balanced with box and two chalks. He replaced the box with 4 chalks so the toy car is balanced with 6 chalks. S6 elaborated and associated the information so he found watermelon is balanced with 6 apples.

3.3. Explain the results of problems that are solved by verbal mathematical models or representations

Based on the result of work and interview from each subject, it is found that S1 and S2 rechecked their work and explained the process. Based on the interview result, the two subjects knew understood the steps done. Besides, S1 an S2 could represent the problem in the form of the mathematical model and
statement. S1 represented the problem by making mathematical model, that is \( 1S = 1P + 2A, 1S + 1A = 1P + 1J, \) and \( 1P = 1J + 1A \) while S2 represented the problem by writing statement. S3 and S5 could not explain the result he got, he could not also represent the problem in other forms. S4 and S5 could represent the problem in other forms using concrete objects, but they could not make the mathematical model. S4 and S6 also rechecked the steps and resolved the problem so they were sure with their answers.

3.4. Discussion
In building an understanding of the problem given, there is a tendency for deaf students to illustrate the problem in the form of visualization. They illustrated the problem in the form of images and also used concrete objects to restate the problem in another form. Deaf students find it easier to understand the problem if the problem is presented in the form of an image. It is because a problem in the form of an image (visual) is very useful for deaf students [9]. In addition, illustrating in the form of images is the best mathematical ability possessed by deaf students [6]. To solve the problem given, there are three categories of ways carried out by the six subjects, namely; substitution, numbering and using concrete objects, enumerating is counting one after another. Deaf students perform oral calculations and calculations using sign language which is a simple arithmetic skill possessed by deaf students [7]. Limitations possessed by deaf students do not become an obstacle for the six subjects in exploring through images, concrete objects, and doing algebraic engineering by substituting, adding up and subtracting the equations that have been obtained. Thus, hearing loss possessed by deaf students is not a direct cause of difficulties in learning mathematics [10] [11] and solving non-routine problems related to connection with daily life. Understanding the problem given is very important in planning a solution and completing it. When deaf students cannot understand the problems presented orally, they will not be able to solve them correctly [12]. Although there are subjects who cannot give the correct answer to the test given, the six subjects have elaborated that is linking the information in the problem with the knowledge that has been formed to get ideas and communicate them through pictures and fiddling with objects - concrete things to solve the problem.

4. Conclusion
Based on the results of mathematical connection ability analysis of deaf students in completing tests related to social arithmetic concluded that deaf students can solve non-routine problems with a high level of difficulty by using the method of substitution, enumerating, and tinkering with concrete objects by first visualizing the problem in the form of images and utilizing concrete objects.

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