Mathematical word problem solving abilities of hearing-impaired students

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Abstract. One of the useful methods to facilitate the students in understanding the benefits and real application of mathematics in real life is by formulating the problem in words. Unfortunately, the previous studies found that students with hearing difficulties usually have limited vocabularies and it becomes a barrier to them in understanding the given context in word problems. Therefore, this study aims at describing the ability of students with hearing-impaired problem in solving mathematical word problems by examining the mathematical skills performed. Since the purpose is to describe a phenomenon, qualitative approach with case study design was deliberately chosen as the method of the study. The subject of the research was eight seventh grade students of School for the Hearing-Impaired in Singaraja, Bali-Indonesia. The data were collected through written test and interview. Afterwards, the data were analysed qualitatively using descriptive method. The results show that the students with hearing-impaired problem were struggling in solving mathematical word problems due to the lack of understanding of the problem and mathematical concepts. Furthermore, there is no tendency for the students with lower level of hearing difficulties to perform better in solving word problems.

1. Introduction
Students’ learning experience in solving mathematical problems in the classroom should be connected to the real life context, including the one outside mathematics topics [1]. It is in line with the aim of mathematics teaching and learning according to the law of Ministry of Education in Indonesia, Permendikbud No. 58 in 2004, which is to enable students in appreciating the use of mathematics. To provide the chance for students in encountering real life problems, the mathematical problems can be design by using words or stories.

The mathematical word problems using daily life context can support the students to think deductively and see the connection and function of mathematics in real life [2]. Furthermore, it can strengthen the students’ conceptual understanding in mathematics. Not only good to motivate students, mathematical word problems can be used to learn new concept and a number of mathematical skills and to employ it effectively in real life experiences [3,4]. It also support the students’ communication development [5], reasoning and connection [6,7] and encourage a meaningful classroom discussion [4]. Without learning the application of mathematics, the students will easily forget what they learn in mathematics.

Mathematical word problems were considered as difficult for regular students [7–13]. To reveal the difficulties, students’ error in solving word problems usually be evaluated using Newman Error
Analysis (NEA) [14]. Newman suggested five crucial activities to find the error of students, i.e. reading, comprehension, transformation, process skills and encoding. It can be classified into two major groups which are Linguistic Proficiency (reading and comprehension) and Conceptual Understanding and Ability of Mathematical Processing (transformation, process skills and encoding) [14].

In the previous studies related to difficulties in solving word problems which subject is regular students, there are several important findings as follows. The students usually find it difficult to understand the problem if it is formulated in words, if the problems merely presented in mathematical expression the students will be able to solve it [7, 8, 10, 13, 14 & 15]. According to Ifanali, the students were hardly transforming the daily word problems into mathematical statement [10]. They also have a lack of mathematical understanding [8] and counting skills [11] that hinder them to solve the problem. Furthermore it was found that there is a connection between students’ mathematical abilities and students’ abilities to solve word problems [18].

The study related to the mathematical word problems of hearing-impaired students were not as common as the regular students. Therefore, the present study will focus on the students’ mathematical abilities in accordance to their hearing-impaired level. Based on the mathematical skills, students comprehension can be classified as high, fair and low [18]. On the other hand, based on hearing loss levels, the students can be classified as mild hearing losses (MiHL), moderate hearing losses (MoHL), severe hearing losses (SHL) profound hearing losses (PHL) and total hearing losses (THL) [19].

According to [20], the problems in hearing leads to the difficulty in learning mathematics. Since the characteristics of students with hearing difficulties are different with the regular one, we need a specific study to understand how they cope with mathematical word problems. By that, we can identify what kind of support will be meaningful for them to learn mathematical problem solving.

2. Method
The aim of the study is to deeply explore the students with hearing-impaired problems’ skills in solving mathematical word problems. Therefore, case study had deliberately chosen as the design [21]. The participant of the study were eight students (two males, six females) in the seventh grade at a special school for hearing-impaired students located in Singaraja, Bali-Indonesia.

The mathematical abilities of the participants were classified based on students’ scores in mathematics lesson. The minimum competence standard for mathematics the school was 75. Hence, we classify the students according the range of score in the Table 1.

| Category | Range of the Score | Number of Students |
|----------|-------------------|--------------------|
| High     | $85 \leq x \leq 100$ | 0                  |
| Fair     | $75 \leq x < 85$   | 2                  |
| Low      | $0 \leq x < 75$    | 6                  |

As can be seen in Table 1, based on mathematical skills, there were only 2 groups of students in the present study namely fair and low. No student was having score greater than 85. Afterwards, we classify the students based on hearing loss as can be observed in Table 2.
Table 2. Students’ Hearing Loss Category

| Hearing Loss Level | Loss Frequency (dB) | Number of Students |
|--------------------|---------------------|--------------------|
| MiHL               | $15 < x \leq 30$   | 0                  |
| MoHL               | $30 < x \leq 60$   | 1                  |
| SHL                | $60 < x \leq 90$   | 6                  |
| PHL                | $90 < x \leq 120$  | 0                  |
| THL                | $120 < x$          | 1                  |

To gather the data, the participants were working to solve essay test consist of four mathematical word problems. After that, a short interview were applied by using guidance to support the Newman’s error analysis as follows [14].

- Please read the question to me. If you don’t know a word, leave it out.
- Tell me what the question is asking you to do.
- Tell me how you are going to find the answer.
- Show me what to do get the answer. “Talk aloud” as you do it, so that I can.
- Now, write down your answer to the question.

The collected data were analyzed using descriptive quantitative and qualitative methods. The students’ scores in solving the word problems will be classified as in the Table 3 [22].

Table 3. Students’ Category in Solving Mathematical Word Problems

| Range of the Score | Criteria                  |
|-------------------|---------------------------|
| $\bar{x} > M_1 + 1.8 SDI$ | Very High                |
| $M_1 + 0.6 SDI \leq \bar{x} \leq M_1 + 1.8 SDI$ | High                     |
| $M_1 - 0.6 SDI \leq \bar{x} \leq M_1 + 0.6 SDI$ | Fair                     |
| $M_1 - 1.8 SDI \leq \bar{x} \leq M_1 - 0.6 SDI$ | Low                      |
| $\bar{x} < M_1 - 1.8 SDI$ | Very Low                |

Noted:
$M_1$ is Ideal Mean = $\frac{1}{2} \times$ (Score Maximum Ideal + Score Minimum Ideal)

$SDI$ is Ideal Standard Deviation = $\frac{1}{6} \times$ (Score Maximum Ideal + Score Minimum Ideal)

The students’ type of errors will be analyzed qualitatively using Flow Analysis Model [23] by doing data reduction, displays and verification. The types of error presents in Table 4.

Table 4. Types of Errors

| Newman’s Types of Error | Prakitipong & Nakamura’s Types of Error |
|-------------------------|----------------------------------------|
| Reading (E1)            | Linguistic Fluency                     |
| Comprehension (E2)      |                                        |
| Transformation (E3)     | Conceptual Understanding and Ability of Mathematical Processing |
| Process Skills (E4)     |                                        |
| Encoding (E5)           |                                        |
3. Results and Discussion

After conducting the test, the students’ responses were evaluated using analytical rubric with maximum score as 10 for each number. Therefore, the score maximum ideal was 40. The students’ problem-solving results can be seen in the Table 5.

| Table 5. Students’ Problem-solving Results |
|-------------------------------------------|
| **Descriptive Statistics** | **Mathematical Abilities** | **Hearing Loss Level** | **Total Score** |
|                            | Low | High | MHL | SHL | THL |
| Average                   | 4.33 | 36   | 2   | 16  | 0   |
| Classification            | Very Low | Very High | Very Low | Fair | Very Low | Low |
| Total Score               | 12.25 |

As is written in the Table 5, the average of students’ scores in solving mathematical word problems were low. The result was not surprising since word problems were considered as difficult for regular students in Indonesia [8,9,15,16]. Furthermore, it can be seen that the group of students based on their initial mathematical skills perform differently to solve the mathematical word problems. According to the previous studies, the students with lower mathematical skills need more time to repeatedly read the problems compare to the students with higher mathematical skills [24]. Also, the students mathematical conceptual understanding plays important role to determine the students’ success in solving the mathematical word problems [25].

However, the level of hearing difficulties not influenced the mathematical skills. It can be seen the students with harder hearing problems performed better than those in mild level. This result is contrary with the study of Irmawati [18] which found that the hearing difficulty levels impact the students’ mathematical achievement. Further study needed to find more empirical evidence to determine whether the hearing problems impact the students’ mathematical learning outcome.

To gain better understanding, the students’ responses were analyzed further based on Newman Error Analysis. The students’ errors in each problem were pointed out to detect which part become the most struggle for them. The result can be observed in the Table 6.

| Table 6. Students’ Type of Error |
|----------------------------------|
| **Error** | **The Percentage of Students doing Error in** |
|          | **Problem 1** | **Problem 2** | **Problem 3** | **Problem 4** | **Total (%)** |
| E1       | 3 (37.5%)     | 6 (75%)       | 5 (62.5%)     | 5 (62.5%)     | 19 (59.375%)  |
| E2       | 4 (50%)       | 6 (75%)       | 5 (62.5%)     | 5 (62.5%)     | 20 (62.5%)    |
| E3       | 4 (50%)       | 7 (87.5%)     | 6 (75%)       | 6 (75%)       | 23 (71.875%)  |
| E4       | 5 (62.5%)     | 7 (87.5%)     | 6 (75%)       | 6 (75%)       | 24 (75%)      |
| E5       | 5 (62.5%)     | 8 (100%)      | 6 (75%)       | 6 (75%)       | 25 (78.125%)  |

Based on Table 6, it can be inferred that 59.375% of hearing-impaired students were struggling in understanding the problems. Therefore, the students were making a lot of errors started from the reading level. Most of the students were unable to understand some words or symbols written in the test problem. It hinders them to move to the next step in finding the solution. Furthermore, 62.5% students were reported to understand the information given in the problems.

Furthermore, the participants were also working to solve routine problems with the same logical structure as in the given word problems. From the analysis, 75% of the students were not be able to solve it correctly (see the example of student’s answer in Figure 1).
This findings showed the similar tendency as previous studies in which the students usually failed in solving word problems but might be true in solving the problem if it is written in mathematical expression only [7,10,15]. For the hearing-impaired students, the failure in solving the word problems is not only because the initial mathematical skills were low, but also due to inability in understanding the problems.

In term of insufficient basic mathematical abilities, the students with hearing problems were reported to have difficulties in doing mixed number operation, such as addition, subtraction, multiplication and division [26–29]. These skills are highly important in solving mathematical problem.

In term of reading fluency, to be able to solve word mathematical problems, the students have to understand the given information [30]. The regular students were previously reported to have difficulties in understanding word problems [7,9,10,14,15]. In this study we can confirm that the students with hearing problems encountered the same problems. It can be seen since 62% of students failed to understand the information given in the problem. To confirm this, consider the summary from interview parts of this study to figure out the students’ difficulties in reading fluency category.

We asked the students to reconsider the given problems and tell the researchers what are the words that they don’t understand. The unknown words and the number of students who do not know the meaning of it were presented in the Table 7.

| Problem | Unknown/Difficult Words | Number of Students |
|---------|--------------------------|--------------------|
| 1       | Marble                   | 3                  |
| 2       | Profit/Loss              | 6                  |
| 3       | -                        | -                  |
| 4       | Pocket Money             | 5                  |

Figure 1. Mathematical counting (1) and word (2) problems
Additional information for problem number 4, the students were actually understood all words in the problem but since the sentence was complex, five of them were incorrectly solve it since they cannot understand the meaning of the whole sentence.

We also confirmed the reason behind the students’ inability in pointing the requirement of the problem. Since the students who failed in reading phase will not be able to continue to the next steps, we only interviewed the students who success in reading but failed in the second step about comprehension. For instance, in solving the first problem, a student (S1) understood that initially there are 16 + 15 marbles while in the end there are 25 marbles in the bag. However, S1 was not be able to determine what the mathematical operation to be implemented is. S1 is hardly connecting mathematical ideas with the context of the problem. Hence, S1 merely able to rewrite the given information.

4. Conclusion
Based on the results and discussion, it can be concluded that the hearing-impaired students’ abilities in solving mathematical word problems were low. Besides due to difficulties in understanding the problems, it also happened due to lack of mathematical conceptual understanding. Therefore, the students with higher mathematical skills were performing better in solving mathematical word problems. Furthermore, it was found that the hearing loss levels were not impacting the students’ mathematical skills abilities since there is no tendency that the students with lower hearing difficulties got higher scores than those with harder hearing difficulties. For further study, it is recommended for conducting larger scale study to draw the generalization of the result. Also, it is necessary to consider the verbal skills of the students with hearing difficulties as it become essential support in understanding word problems.

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