Hearing-impaired student ability to solve the problem in math

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Abstract. The research objective is to explore the mathematical connection capabilities of hearing-impaired students in grade 8 in completing tests related to connection with other disciplines. The type of research used is qualitative research with a case study design. The number of subjects in the study was six people who were taken purposively based on the characteristics of language and speech, intelligence, and social-emotional spread in 3 schools namely; SLB B KaryaMurni of Ruteng - East Nusa Tenggara (NTT), State SMPLB Semarang and SLB B Don BoscoWonisobo. The results of the analysis of work and interviews found that mathematical connection abilities that arise in hearing impaired students in completing tests related to connection with other disciplines include; (1) in building an understanding of the problem, hearing impaired students tend to represent problems by making pictures. (2) in making a preliminary plan to complete, the students are inclined to use the media related to the problem given. (3) if hearing impaired students can find patterns by seeing regularity, then in determining these patterns they tend to use the results of exploration by making pictures. Thus concluded that hearing impaired students can solve non-routine questions with a high level of difficulty by using the patterns found by first exploring through images.

1. Introduction

Mathematical connection capability is one of the abilities that middle school students need to have both normal students and hearing-impaired students. The importance of having the ability to connect mathematics is contained in the objectives of school mathematics learning, among others; understanding mathematical concepts, explaining the relationship between concepts and applying concepts or logarithms flexibly, accurately, efficiently and precisely in problem-solving. The ability of mathematical connections can be understood as a cognitive process that requires effort to find relationships between representations of concepts and procedures, understanding between topics, and applying these mathematical concepts in other fields or in everyday life. Hearing impaired students have mathematical connection skills to assist in building an understanding of concepts and helping hearing-impaired students to solve problems through interrelationship between mathematical concepts and other disciplines.

Hearing impaired students are students who experience hearing impairment, both in part and in whole, which have a complex impact on their lives. Limitations possessed by hearing-impaired students in terms of obtaining information, influence the efforts in building mathematical connection abilities. Deaf students do not use the cognitive potential possessed to the maximum extent in processing information because it is influenced by limitations in communication and problem solving [1]. There are differences in mathematics learning outcomes between deaf students and normal students. Deaf students who experience delays in arithmetic performance. Language mastery disorders affect their
ability to solve arithmetic problems [2]. Deaf students who experience delays in arithmetic performance. Language mastery disorders affect their ability to solve arithmetic problems [3]. Hearing impaired students have limitations in hearing, which does not mean that hearing-impaired students cannot study mathematics and complete math tests. The limitations that they have, can be overcome by the advantages they have, namely visual skill [4]. The advantages of hearing-impaired students are mathematical abilities in fields, spaces, and measurements that use visuospatial skills [5]. "literacy" skills are very important in teaching mathematics which allows students to learn how to process visual aids that support reading comprehension for deaf children [6]. Besides visual, hearing impaired students also have simple arithmetic skills in performing oral calculations using sign language and The deaf children used the same general types of strategies that are used by hearing children (i.e., modeling, counting, and fact-based strategies), they showed an overwhelming use of counting strategies for all types of problems [7]. By utilizing the advantages possessed by hearing-impaired students in terms of visuals and simple arithmetic skills, researchers want to explore and express the mathematical connection abilities possessed by hearing impaired students by providing mathematical tests related to connections with other disciplines.

2. Methods
The type of research used is qualitative research with a case study design. The researcher used a case study design to explore and express in depth and in detail the subjects to be studied using various procedures in collecting data, namely providing tests related to connections with other disciplines and in-depth interviews of work [8]. The number of subjects in the study was six people who were taken purposively based on the characteristics of language and speech (S1 and S2), intelligence (S3 and S4), and social-emotional (S5 and S6). The student were from 3 schools namely; SLB B KaryaMurni of Ruteng - NTT, State SMPLB Semarang, and SLB B Don BoscoWonosobo. Following are the problems given to research subjects

One bacterium
itself to double
every 5 minutes

Figure 1. The problem was given to the subjects

3. Result and Discussion
There are several findings obtained by the researcher when subjects completed a mathematics test related to other disciplines. These findings refer to two indicators of achievement in connection with other disciplines namely (1) determining the relationship between topics with other disciplines (2) applying mathematical thinking and modeling to solve problems. The results of the analysis of each indicator are presented as follows;
3.1. *Determine the relationship between topics with other fields science*

Based on the findings and interviews, it was found that there were four subjects (S1, S2, S5, and S6) knowing that bacteria or germs were present in science lessons, especially in Biology. S1 and S5 suggest that bacteria or germs can cause disease, while S2 and S6 say that bacteria are viruses that can cause disease. In the opinions above, the researcher saw that the four subjects knew that bacteria was a type of virus that could cause disease. The four subjects have carried out information elaboration, namely linking the information obtained (bacteria) to problems with the knowledge that has been formed previously, namely the germs of disease that exist in the Biology Science lesson. From the interview results, there was obtained information that the S3 did not know about bacteria. He uses a dictionary to find synonyms of the word bacteria. This is done by S3, and hearing impaired students in general to overcome the lack of vocabulary they have. S4 knows about bacteria and bacteria including living things that are studied in biology subject instead of in mathematics.

3.2. *Applying mathematical thinking and modeling to solve problems*

Based on the findings, there are two categories of ways carried out by the six subjects in representing the problem, namely making an image and making a list.

3.2.1. *Make a picture*

Of the 6 subjects in this study, there were 5 subjects (S1, S3, S4, S5, and S6) representing the problem by making a circular image. From a circular image, each subject explores different ways to link information to problems with images created which are analogized as bacteria that divide every 5 minutes.

![Figure 2. Category by making pictures](image)

In Figure 2, it is known that S1 creates a circular image showing one bacterium before dividing. S1 makes a line that divides the circle area into 2 parts to show the bacteria defend themselves in the first 5 minutes. Not all the minutes he made in the form of pictures. He made it in pictures until the 25th minute and got 32 bacteria. In Figure 1 it is also seen that S3, S4, S5, and S6 have an initial plan to solve the problem as well by making an image. From the results of the interviews, the four subjects said that making in the form of images would be "easier" to understand. The four subjects carried out the plan by making one round and making two lines and connected to two new circles indicating that the bacteria split in two. S3 and S4 make images until the 30th minute and get 64 bacteria. Whereas S5 and S6 make images up to 15 minutes and get 8 bacteria.

3.2.2. *Making a list*

S2 represents the problem by making a list. He does not use the media to illustrate the problem. He communicates ideas by writing similarities between the number of bacteria obtained at a certain time. However, the mathematical model he wrote, as shown in Figure 3 below, is a mathematical concept that is not true, namely $2 = 5$ minutes, $4 = 10$ minutes, etc. When interviewed, he said that 2, 4, 8, and 16 stated the number of bacteria after 5 minutes, 10 minutes, 15 minutes and 20 minutes.
Based on the results of the interview it is known that he understands the time every 5 minutes as a multiple of 5. He calls back the knowledge that has been formed about multiples and associates that knowledge with the information obtained. The thought process built by S2 by not using the media as a bridge between concrete things and abstract things shows that the level of cognitive development is at the level of thinking things that are abstract. Based on Figure 2 above, it appears that he wrote the relationship between the number of bacteria and the time taken until the 20th minute, and got 16 bacteria.

To answer questions related to how much bacteria after 1 hour, the six subjects completed by first seeing an order that appeared based on the results of exploration through images. This order appears, hereinafter referred to as a pattern. There are 2 categories of patterns obtained by the six subjects namely; multiplied by 2 and raised by 2.

a). Multiplied by 2. There are 4 subjects, namely (S1, S2, S3, and S4) who find patterns multiplied by 2. They explore through images to find a pattern and use the pattern to answer questions related to the number of bacteria after 1 hour as in Figure 4 below.

In Figure 4, it is known that S1 and S2 have the same initial plan, that is, the results obtained are made in rows, while S3 and S4 write vertically which both start from the 15th minute. S1 and S2 write the number of bacteria in the row; 1, 2, 4, 8, 16. Both subjects made the guesswork by taking one example, namely that he said that if after 20 minutes there were 16 bacteria then after 20 + 5 minutes there would be 16 x 2 bacteria. To prove that the allegation is true, the two subjects tested their argument by taking the number of bacteria in the 5th minute, namely 2, 10 minutes, namely 4, 15 minutes, namely 8 where 1 x 2 = 2, 2 x 2 = 4, 4 x 2 = 8. This process is continued so that it gets 16 = 8 x 2 = 16, 16 x 2 = 32, 32 x 2 = 64. To calculate the number of bacteria after 60 minutes, S3 and S4 no longer make in the form of images. The results of interviews with S3 and S4 note that making the picture until the 60th minute "there will be lots of pictures and length". Based on the results obtained until the 15th, S3 and S4 minutes saw a relationship between the number of bacteria with a certain time, namely; 8, 16, 32 where 8 x 2 = 16, and 16 x 2 = 32. This process continues until 60th minute.

Regarding the process carried out by the four subjects above, the researcher saw that the thought process that was built started from seeing the relationship between certain times, namely 5, 10, 15, 20, etc. with many bacteria, namely 2, 4, 8, 16, 32, etc. Based on the relationship between the number of bacteria within a certain time, all four subjects made predictions. Making an assumption shows that the thinking process that is built by the four subjects is no longer limited to concrete things, but has already
thought about things that are abstract. These allegations are then tested by taking several cases so that finding an order that appears as if after a minute there are n bacteria then after a + 5 minutes there will be n x 2 bacteria. This emergence is referred to as a pattern which is then used by all four subjects to calculate the number of bacteria after 1 hour (60 minutes).

b). Raised by 2. To calculate the number of bacteria after 60 minutes, S5 and S6 no longer make in the form of images. From the results obtained, that is after 5 minutes there are 2 bacteria, after 10 minutes there are 4 bacteria, after 15 minutes there are 8 bacteria and after 20 minutes there are 16 bacteria, then S5 and S6 make as shown below.

![Figure 5. Category raised by 2](image)

In Figure 5, S5 and S6 see an order that is at 30 minutes (2 x 15), there are 64 (82) bacteria. To test the regularity, both S5 and S6 count the number of bacteria after 40 minutes, that is, (2 x 20) and the number of bacteria is 256 (162). So to calculate the number of bacteria after 1 hour (2 x 30) then the number of bacteria is 642 = 4096. S5 also says that to calculate the number of bacteria after 2 hours is equal to 4096 x 4096. Seeing an order that arises from a particular process in mathematics shows that the thinking process that is built by both subjects is no longer limited to concrete things, but has already thought about things that are abstract. But for both hearing impaired subjects and students in general, the use of media is very important in learning mathematics to bridge between concrete things to abstract things. The order that appears is tested in several other cases so that the order becomes a pattern that is; if after a minute there are n bacteria then after a x 2 minutes there will be n2 bacteria. This pattern is then used by both subjects to calculate the number of bacteria after 1 hour (60 minutes) i.e. 60 minutes (2 x 30), there are 642 = 4094 bacteria.

Based on the results of an analysis of the ability of mathematical connections in the six subjects in solving problems related to other disciplines, acquired abilities that arise in hearing-impaired subjects include; (1) The subject understands the problem given by illustrating the problem in the form of an image and making a list. (2) Subjects are able to make plans to solve problems. (3) Subjects can determine the relationship between topics on the given problem, namely the six subjects know that the problem given is related to the field of biological studies. (4) Subjects can make simple patterns in solving problems (5) Subjects re-examine the results of the completed work in which the six subjects checked the number of bacteria using the pattern found.

In building an understanding of the problem given, there is a tendency for hearing impaired students to illustrate the problem in the form of pictures. Visual literacy skills are very important in teaching mathematics which allows students to learn how to process visual aids that support reading comprehension for deaf children [6]. Representing the problem in the form of an image shows that the thinking process built by each subject starts from semi-concrete things leading to abstract things. Hearing impaired students find it easier to understand the problem if the problem is presented in the form of an image because it presents a problem in the form of an image (visual) is very useful for hearing impaired students and deaf children use visual acuity which is their strength in the learning process to improve language development and communication [9]. In addition, illustrating in the form of images is the best mathematical ability possessed by hearing-impaired students. To solve the given problem, the six subjects explored through images to find an order that emerged and the order was called a pattern.
There are two found, multiplied by 2 and raised by 2. Hearing impaired students use the pattern to perform oral calculations using sign language which is a simple arithmetic skill possessed by hearing-impaired students [2]. The disadvantages possessed by hearing-impaired students do not become obstacles for the six subjects in doing isolation through images, finding patterns, and doing calculations to answer questions. Although they cannot make a general formula for calculating the number of bacteria, they have managed to find a simple pattern that is used to answer questions related to many bacteria after 1 hour. The deaf children used the same general types of strategies that are used by hearing children (i.e., modeling, counting, and fact-based strategies), they showed an overwhelming use of counting strategies for all types of problems [7]. Thus, hearing loss possessed by hearing impaired students is not a direct cause of difficulties in learning mathematics and solving problems [10]. In deaf children, most mathematical performance depends on basic skills including mental calculations, a speed of comparison of numbers, and guessing skills which are mostly of self [11]. They are used the same general types of strategies that are used by hearing children (i.e., modeling, counting, and fact-based strategies), they showed an overwhelming use of counting strategies for all types of problems and at all ages [12]. Based on the results of an analysis of the ability of mathematical connections in the six subjects in solving problems related to other disciplines, acquired abilities that arise in hearing-impaired subjects include; (1) The subject understands the problem given by illustrating the problem in the form of an image and making a list. (2) Subjects are able to make plans to solve problems. (3) Subjects determine the relationship between topics to the problem given, namely the six subjects know that the problem is related to the field of biological studies, namely bacteria or viruses that cause disease. (4) Subjects can make simple patterns for solving problems. (5) Subjects re-examine the results of the completed work in which the six subjects checked the number of bacteria using the pattern found.

4. Conclusion

Based on the results of the mathematical connection ability of hearing-impaired students in completing mathematical problem related to connection with other disciplines it was concluded that hearing impaired students can solve non-routine questions with a high level of difficulty by using the patterns found by first exploring through images.

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