Mathematical Representation of Deaf Students in Problem Solving Seen from Students’ Creative Thinking Levels

Y Arnidha1*, Hidayatulloh1
1STKIP Muhammadiyah Pringsewu Lampung
*yunniarnidha@stkipmpringsewu-lpg.ac.id

Abstract. Mathematical representation is an important ability to be developed and must be owned by students. Representative ability is centered on mathematical studies that encourage students to be able to develop problem-solving skills based on students’ high-order thinking, one of which is creative thinking. This study aims to analyze the mathematical representation of deaf students in solving mathematical problems in terms of the level of creative thinking. This study uses a qualitative approach with research subjects consisting of 5 deaf students in the fifth grade of SDLB (extraordinary elementary school) Pringsewu 2017/2018 academic year. Collecting data by providing test questions about mathematical problem solving then interviewed the students about mathematical representation in solving a problem. Data in the form of research is data test results and interviews. The results showed a number of 5 students could solve problems seen from various levels of creative thinking. In the problem-solving process, the most prominent mathematical representation of students is the visual representation. As many as four students have the ability to visually represent mathematics in solving problems in terms of the level of creative thinking. As many as one students are able to understand the problem-solving abilities of equations or mathematical expressions and problem-solving in verbal abilities in the form of words or written texts. In addition, there is also one student who does not understand the question given and has not been able to answer the question in the right way. There is one student at the lowest level, namely level 0 (not creative). There are 3 students at level 1 (almost not creative) and 1 student at level 3 (creative).

1. Introduction
Education is a form of efforts to improve the quality of human resources. Awareness of the importance of education has encouraged various efforts and attention of the entire community towards every development of education. In line with the development of science and technology, the government also strives for innovation in education at the primary, secondary to tertiary education levels including the education of children with special needs. As Keil & Cobb said that [1] Special Educational Needs and Disability Act could lead to a greater understanding of the need to make a school accessible to wheelchair users, or provide a pupil with curriculum materials in Braille, which were often regarded as something to be ‘added on’ to what is available as standard. This opinion gives an understanding that the school curriculum should need a standard curriculum for children with special needs.

Deaf children are children with special needs who have impairments or deficiencies in the auditory senses caused by the failure of some or all of the hearing devices. As Shick et al assumption that [2] “many deaf children have difficulties with language comprehension, it is possible that performance on the verbal tasks is limited by the children’s language skills…” This opinion shows that deaf children have language difficulties. Language disability is caused because children are unable to hear. A hearing function that cannot work optimally has a complex impact on the lives of deaf children [3]. Depending on the situation, many of those individuals support their speech with signs to a greater or lesser extent.
As in learning activities, deaf students experience obstacles in development that affect the process of delivering material. The intelligence of deaf children is potentially the same as normal children, but functionally their development is influenced by language ability, limited information, and the power of child abstraction. As revealed by Jones, [4] as long as they are able to engage in purposeful communication their cognitive ability is unaffected and it may be that for signing children with oral parents, it is the ‘mismatch’ of communication styles which negatively affects their cognitive ability. This will make students experiencing difficulties in constructing the core of the lesson through the ears and experiencing difficulties in expressing their thoughts through language. Even though the intelligence is normal, children who have hearing impairments will experience difficulties in understanding abstractly, so that it will hinder the process of achieving knowledge without the exception of mathematical knowledge.

Each student has a different way of constructing his knowledge. In this case, it is very possible for students to try various representations in understanding a problem. According to Sabirin, [5] representation is a form of interpretation of students' thinking on a problem that is used as a tool in finding solutions to student problems in learning activities. Representation can be in the forms of words, writing, pictures, tables, graphs, and mathematical symbols, and according to the ability of the student. In this regard, [6] Representative ability has an important role in processing numerical information that depends on mathematical knowledge, statistical knowledge, reading ability, and literacy skills. In addition, representation also has an important role in mathematical problem-solving. Through representation, students can manage their thinking processes and are useful to make mathematical ideas more concrete and deal that is useful as a material for thinking.

Students who have hearing disorders, like other normal children, they have the ability to understand the knowledge. However, in reality, many deaf students experience difficulties in understanding, especially mathematics, due to limitations in listening and communicating. Mathematical representation is very necessary as a foundation and foundation for students in learning mathematics to understand and use mathematical ideas. There are several forms of mathematical representations, such as diagrams, graphs, expressions, and symbols which are essentially part of a long activity of mathematics. This is in line with the opinion of Hwang et al that [7] in solving mathematical problems, students are encouraged to observe and find specific patterns in the problem. Students need to formulate problems into forms of abstract mathematical problems. Dahlan & Juandi added that [8] actual representation does not show new or different results or products or constructs, but through a thought process carried out to be able to uncover and understand the concepts, operations, and mathematical relationships of a construct. In addition to solving mathematical problems, students are also directed to be able to think creatively in order to improve the quality of human Indonesia as a human resource that is beneficial in all sectors of life.

When doing activities, humans use the mind to solve problems. At present, problem-solving skills must be instilled in students at every level of education including in special schools. Even though students have limitations, the teacher needs to instill these skills for their provision in living various life activities [9]. Problem solving represents a higher intellectual activity, regarded by the majority of experts as the most complex level of cognitive activities that mobilizes at the same time, all of the individual's intellectual faculties: memory, perception, reasoning, conceptualization, language and they equally involve emotions, motivation, self-confidence and ability to control the situation. Shiakalli & Zacharos added [10] in learning activities, problem-solving can be used to train mathematical abilities such as addition, subtraction, identifying forms, reading graphics, and displaying graphs in accordance with the objectives. This shows that mathematical representations are closely related to solving activities student problems in learning activities, especially in mathematics learning. The decision-making process in solving problems requires human creativity in thinking. Creative thinking is part of high order thinking skills that must be possessed. According to Nadeem, [11] creative thinking is an important human characteristic. Piawadded [12] the ability to think creatively can also be interpreted as activities to find problems (identify problems), efficiency (generate ideas), flexibility (generate ideas that characterize flexible understanding), originality (produce unique ideas), and elaborate (expanding ideas). Creative thinking skills can also be interpreted as activities to find problems (identify problems), efficiency (generate ideas), flexibility (generate ideas that characterize flexible understanding), originality (generate unusual ideas), and elaborate (develop ideas). With creative
thinking, humans can develop the potential that exists in themselves and can view a problem from various perspectives.

To see mathematical representations in completing mathematical problem-solving in terms of students' creative thinking, there needs to be a valid criterion of creative thinking, creative thinking criteria can be used as clues to find out how students think creatively and their development during the learning process. There needs to be a benchmark or criteria for a level of creative thinking that is valid, creative thinking criteria can be used as a guide to knowing how students think creatively and developmentally during the learning process. The following is the hierarchy level in the level of mathematical creative thinking in proposing and solving problems, namely [13]:

| Level  | Karakteristik                                                                 |
|-------|-------------------------------------------------------------------------------|
| Level 4 | Very creative Students are able to solve a problem with more than one alternative answer or how to solve or make problems that are different smoothly and fluently. Students who reach this level can be named as very creative students. |
| Level 3 | Creative Students are able to show a new answer in a different (flexible) solution even though it is not fluent. In addition, students can make different problems smoothly (fluently) despite the answer to a single problem or create a new problem with divergent answers. Students who reach this level can be named as creative students. |
| Level 2 | A little creative Students are able to make one answer or problem that is different from the general habit even though it is not flexible or eloquent, or is able to show various different ways of solving fluently even though the answers produced are not new. Students who reach this level can be named as quite creative students. |
| Level 1 | Almost not creative Students are not able to make answers or make new different problems, even though one of the following conditions is met, namely the way of solving that is made different (flexible) or the answers/problems that are made very (fluent). Students who reach this level can be named as less creative students. |
| Level 0 | Not creative Students are not able to make alternative answers or ways of solving or making different problems fluently and flexible. Students who reach this level can be called non-creative students. |

2. Research Method

This research is a qualitative descriptive study. This study aims to study qualitatively mathematical representations of deaf students in solving mathematical problem-solving problems in terms of their level of creative thinking. Subjects in this study were five deaf students in the fifth grade of SDLB (extraordinary elementary school) Pringsewu. The research instruments in this study were problem-solving and interview test questions. The problem-solving test consisted of four questions to find out how the mathematical representation of students in problem-solving is viewed from the level of creative thinking. The first question shows a visual representation in the form of an image. The second problem shows mathematical equations or expressions. The third and fourth questions show verbal representation by showing words or written text. Test questions have been validated by validators who are competent in their fields. Interviews in this study use structured interviews. The questions asked to develop according to the students' answers. In the interview process, deaf students are guided by a companion teacher to connect communication between the interviewer and students. Data analysis techniques used in this study include data reduction, data categorization, and data synthesis.

3. Result and Discussion

3.1 Analysis of problem-solving test questions in terms of the level of students' creative thinking

Problem-solving test in terms of students' creative thinking is held on Monday, April 2, 2018. The results of the problem analysis to find out the mathematical representation of deaf students in solving problems in terms of creative thinking levels are presented in the following table
Table 2 The results of the test questions analysis

| Subject | Creative thinking level | Information |
|---------|-------------------------|--------------|
| FSS     | 0                       | Subjects have not been able to show what is known and asked about the problem. Not able to show good pictures. Not able to make conclusions and make other steps in solving problems with the problem. |
| JS      | 1                       | Subjects have not been able to show what is known and asked about the problem and have not been able to make conclusions and make other ways of solving the problem given. But it has been able to show images well according to the request on the problem. |
| HR      | 1                       | Subjects have not been able to show what is known and asked about the problem. Not able to make conclusions and make other steps in solving the problem. But you have shown the picture well according to the instructions on the problem. |
| AZ      | 1                       | Subjects have not been able to understand what was asked about the problem, not able to make conclusions and use other methods in solving problems, and not able to make conclusions and use other methods in solving problems. But it has been able to show pictures well according to the instructions on the problem. |
| JR      | 3                       | Subjects have not been able to show what is known in the problem. Already able to show pictures well according to the instructions on the questions and have been able to make conclusions and solve problems in other ways. |

Based on Table 2, there are three deaf students having mathematical representation in problem-solving in terms of the level of creative thinking at level 1 (less creative). One student is at the third level of creative thinking. At the 3rd level, students are classified as creative students, where students are able to show a new answer in a different (flexible) way of solving even if they are not fluent or make new answers even if not in a different (inflexible) way. In addition, students can make different problems smoothly (fluently) despite the answer to a single problem or create a new problem with divergent answers. Then, there is still one student in level 0 creative thinking (not creative). At this level, students are not able to make alternative answers or ways of solving or making different problems fluently and flexible. These results are seen from the sample student answers that will be presented in the following picture.

![Figure 1 Representation in the visual form of creative thinking level 0](image)

The results show that the FSS cannot restate what data is the command on the problem, it is not even able to make a picture of a cassava tree that must be divided into 3 plots of land, in the sense that the FSS subject is unable to provide what information is known and what is asked on the question. Thus
the researcher concludes that FSS subjects do not have the visual ability in the form of the restatement of data or images that are according to the instructions on the problem.

Figure 2 Representation in the form of equations or mathematical expressions of creative thinking level 0

The results of the answers show that students do not have the ability of equations or mathematical expressions in the sense that the students have not been able to display or make a fraction of the equation ordered in the problem. Thus FSS students have not been able to demonstrate the ability of equations or mathematical expressions.

Figure 3 Representation in verbal form in creative thinking level 0

The answer results indicate that the student does not have a mathematical idea that is displayed by writing down the steps of solving mathematical problems in a row or with words or composing a story in accordance with a representation that is presented or answering the problem in words. The FSS sub-committee still answers what is not ordered in the matter, which is drawing an inappropriate answer. FSS answered by writing 0, ½, 2/4, 3/5, 4/8, 1. That way it can be seen that the FSS subject has not been able to describe what was asked in the question order, in the sense that the FSS subject has not been able to solve the mathematical representation problem verbal.

Figure 4. Representation in the visual form of creative thinking level 1

The results of the answers show that the subject has been able to re-present what data is the command on the problem, and even able to make a picture of a cassava tree that must be divided into 3 plots of
land. JS is able to provide what information is known and what is asked about the problem. Thus it can be seen that JS has the visual ability in the form of the restatement of data or images according to the instructions on the problem.

![Figure 5](image1.png)

**Figure 5** Representation in the form of equations or mathematical expressions of creative thinking level 1

Students' answers show the ability of equations or mathematical expressions. JS is able to display or make fraction values similar to what is ordered on the problem, in this case, the student writes the answers correctly by looking at the instructions. Thus, JS students are able to demonstrate the ability of equations or mathematical expressions.

![Figure 6](image2.png)

**Figure 6** Representation in verbal form in creative thinking level 1

The results of these answers indicate that JS does not have a mathematical idea displayed by students by writing down steps to solve mathematical problems in a row or with words, or composing a story that matches a representation that is presented or answers the question in words. JS has shown an image or drew a number line correctly, but in the completion of what was ordered, it is still not right. JS answers by writing 0, 1/4, 2/4, 3/5, 3/4, 1, thus it can be seen that the JS subject has not been able to describe what was asked in the question command. This means that JS has not been able to solve mathematical representation problems verbally in the form of words or written texts.

![Figure 7](image3.png)

**Figure 7** Representation in the visual form of creative thinking level 3
The results of the answers show that JR has been able to re-present the data that is the command of the problem, even JR is able to make a picture of a cassava tree that must be divided into 3 plots of land. This means that JR is able to provide what information is known and what is asked about the question. Thus it can be seen that JR has a visual ability in the form of the restatement of data or images that are according to the instructions on the problem.

**Figure 8** Representation in the form of equations or mathematical expressions of creative thinking level 3

The answer results show the ability of equations or mathematical expressions in the sense that JR students are able to display or make fractional value equations from what is instructed on the problem, in this case, the students write the right answer by looking at the question instructions ie students answer $\frac{1}{2}$, $\frac{2}{4}$, and $\frac{4}{8}$. Thus, JR is able to demonstrate the ability of equality or mathematical expression.

**Figure 9** Representation in verbal form in creative thinking level 3

Results show that JR has a mathematical idea displayed by students by writing steps to solve mathematical problems in a row or with words, or composing a story in accordance with a representation presented or answering questions in words. JR has drawn a number line correctly, in this case, the completion of what was ordered was correct. Thus, it can be seen that JR has been able to describe what was asked in the question order, this means that JR has been able to solve mathematical representation problems verbally correctly.

### 3.2 Interview Result

| Subject | Interview result |
|---------|------------------|
| JS (1)  | Students understand the questions a little. Students can understand problem number 1. Students like to draw, he likes to do questions by drawing and then the results are known. Students use these problem-solving in everyday life, for example in dividing bread/pizza, and others. When faced with another problem, students feel difficulties and are confused by how to do the problem. Thus, students are able to demonstrate the ability of visual representation well. |
Subject

| Interview result |
|------------------|
| **FSS (0)** | Students do not understand the questions given. After reading the questions, students feel confused to do it. Students feel very difficult when working on problem number 3 (to see the ability of verbal representation). Students really don't understand how to do problem number 3, the problem is difficult for students to understand. Students do not feel they have ever found the problem in their daily lives. |
| **HR (1)** | Like students with level 1 creative thinking, students are most easily working on questions number 1 and number 2. Students find it difficult and lack understanding of other questions. That way, students also do not know how to work on the problem. For the answer to question number 1, students sometimes think about the process of solving the problem in their daily activities. |
| **AZ (1)** | Students find it difficult to understand the questions given. He was also confused in working on the problem. AZ students only understand problem number 1 because for AZ the number 1 problem can be described in visual form (cassava tree), making it easier to answer the question. Although he can answer the question, in solving problems in daily activities rarely use that way. |
| **JR (3)** | Students have enough to understand and understand the questions given. Some questions have been answered correctly. After reading the questions, they thought about how to answer these questions in an easy way. They do the questions quite easily, except in problem number 3, they have difficulty in finding the right answer. "I have trouble working on problem number 3, but I can answer it". "I'm easiest to do problem number 1. I understand how to do it". Students are used to using this method in the process of solving simple problems in everyday life. |

**Discussion**

Deaf students are unique in understanding each learning material learned. Although it has limitations, it does not become a barrier for them to get knowledge. The mathematical representation of deaf students in the fifth grade of SDLB (extraordinary elementary school) is more likely to be a visual representation. This may occur because of its limitations in listening and speaking, students more easily understand a problem through images (visual). In accordance with the opinion Cartrette& Bodner that [14] a student can solve problems easily when mastering two types of representations, namely visual and mathematical representations. Butler also said that [15] children's ability to solve mathematical problems is better in terms of symbolic than verbal. Symbolic, in this case, means understanding mathematical representations in the form of symbols or images (visual). Seen in the results of the analysis of students' answers and interviews that mathematical representation in visual form is easier to use in problem-solving than representation in verbal forms and mathematical expressions. As the findings of Butler that [15] one key finding on problem format was that children performed better on symbolic multiplication problems than on word problems. In this regard, in solving problems, creative thinking is needed by students. Every deaf student also has a different level of creative thinking. A number of students belong to level 3 creative thinking, namely, students can be said to be creative. Three students at level 1 creative thinking and one other person are at level 0 creative thinking. The level of creative thinking in creative students can be seen from the students' fluency in answering questions and students' flexibility in solving problems presented in the problem. In accordance with Kyung-Hwa's opinion that [16] "creative thinking ability involves fluency, flexibility, originality, and elaboration". With this level of creative thinking, students' mathematical representation ability in solving problems can be continuously trained so that students are able to implement it in community life. Oppezzo& Schwartz said that [17] creativity has the potential to make a positive contribution to society. The findings of Chu & MacGregor reveal that [18] by simultaneously practicing problem-solving can generate experience in taking complex solutions for both work demands and daily life. It was emphasized by Kultu& Gokderethat [19] the education environment should be able to provide opportunities for students to develop their creative thinking skills, but the current educational environment cannot provide a full opportunity for students to think creatively. By analyzing these results, learning is needed that can accommodate students to think creatively in solving problems.
4. Conclusion

The mathematical representation of deaf students in the fifth grade of SDLB (extraordinary elementary school) Pringsewu in solving problems from the level of creative thinking based on the results of tests and interviews, it can be concluded that a number of 5 students can solve problems seen from various levels of creative thinking. In the problem-solving process, the most prominent mathematical representation of students is a visual representation. As many as 4 students have the ability to visually represent mathematics in solving problems in terms of the level of creative thinking. As many as 1 student is able to understand the problem-solving abilities of equations or mathematical expressions and problem-solving in verbal abilities in the form of words or written texts. In addition, there is also one student who does not understand the question given and has not been able to answer the question in the right way. There is one student at the lowest level, namely level 0 (not creative). There are 3 students at level 1 (not creative) and 1 student at level 3 (creative).

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