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Student Reasoning Based on Mathematical Ability in Solving HOTS Problems through Differentiated Learning

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Abstract. The mathematical abilities of students with reasoning are closely interrelated. The HOTS-type problem is an effort to improve reasoning ability. The ability of students to solve HOTS questions is still relatively low. Through a differentiated learning model, it is expected to help students in the learning process that suits their needs. The purpose of this study is to describe the application of differentiated learning models and describe the mathematical reasoning ability of students who have low, medium, and high abilities. This type of research is qualitatively descriptive with instruments in the form of observation sheets, questionnaires, test questions and interviews. Data analysis techniques include data reduction, data presentation, and conclusions. Test the validity of data using triangulation techniques. The results of this study show that differentiated learning can improve students' ability to reason. Four indicators of mathematical reasoning are, students' ability to present mathematical problems in the form of written statements, students' ability to make conjectures, students' ability to manipulate mathematics, and students' ability to draw conclusions from problems. Subjects with a high level of reasoning meet two indicators. Whereas subjects with moderate levels of reasoning met only three indicators and subjects with low levels of reasoning met only two indicators. Mathematics teachers should provide learning that is in accordance with the learning style of students and students should also do HOTS type questions more often.

Keywords: Differentiated Learning, HOTS Problems, Reasoning

1 Introduction

NCTM (National Council of Teacher of Mathematics) states that mathematics learning standards are needed to produce students with the ability to think creatively, reasoning mathematics, have useful basic knowledge and skills starting from elementary school to high school / equivalent grade XII [1]. In order for students to understand the concepts and principles that have been learned, mathematical reasoning activities need to be carried out.

[2] States that reasoning is a logical thinking activity to collect facts, manage, analyze, explain, and make conclusions. [3] Revealed that reasoning is a way of thinking or line of thinking adopted to create conclusions or statements so that problems can be solved. [4] Stated that reasoning is an activity, a thought process to get a conclusion and to make new statements associated with facts that are known to be true. [5] State that to begin reasoning, students need to understand the concept of a specific math problem and understand what is required of the problem. For this reason, it is necessary to know student reasoning so that teachers can improve reasoning in mathematical problems.

One way that can be used to find out students' reasoning in solving math problems is to provide HOTS (Higher Order Thinking Skill) questions. This is in accordance with the opinion of [1], which states that in doing HOTS type questions we are required to have high-level thinking skills and involve the process of reasoning. [6] Stated that HOTS is a higher-order thinking ability related to a person's ability to think critically, problem-solving, and decision-making. And if it is related to the cognitive level of Bloom, then HOTS is included in the levels of analysis (C4), evaluation (C5), and creating (C6).

However, students' reasoning in solving HOTS questions is still fairly low [7]. In this case, it is in accordance with what [3] stated that the weakness of students' mathematical reasoning ability can be seen from TIIMS 2011 that the average Indonesian student is still far below Singapore, Thailand and Malaysia, namely at the level of reasoning 17%. In solving complex mathematical problems in HOTS type problems, students not only memorize and remember formulas but rather lead to the use of logic [8].

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Statistics is a learning that students get through everyday life, it is very closely related to the HOTS approach which requires students to solve everyday problems [9]. In accordance with the statement expressed by [10] regarding the importance of statistical material that can be developed into the form of HOTS questions with subjects including data, data presentation, data analysis which is important to learn because statistics is closely related to mathematics and various events in everyday life.

For this reason, researchers choose statistical material as a problem to be used in research, because many students still make mistakes in solving HOTS-type statistical problems. The difficulty factor of students in solving math problems in the HOTS category in Statistics material is student errors in reasoning caused by lack of understanding the meaning of the problem and wrong concepts. This is in accordance with the statement expressed by [11], namely the lack of mastery of statistical material, especially in the submaterial of frequency distribution, median, mode and weakness of students in understanding problems, and the lack of students' ability to present data back into pictures or tables is one of the difficulties of students in solving HOTS category math problems in Statistics material.

Previous research related to student reasoning in solving HOTS questions has been conducted. As in the research of [12] which discusses statistical reasoning analysis based on HOTS problems; [11] related to the analysis of students' mathematical representation abilities in Statistics material; [13] who discuss the missolution of HOTS type statistical problems based on Newman's theory. In the research that has been done, it does not use learning models to determine the level of reasoning of students. For this reason, researchers conducted different studies using differentiated learning as a learning model. Teachers can conduct learning by applying differentiated learning so that learning objectives are achieved.

Differentiated learning is one of the efforts to develop and restore current educational conditions [14]. [15] Stated that differentiated learning is a way to create a more diverse class by providing opportunities for students to achieve content, process ideas and improve learning outcomes to run more effectively.

Differentiated learning adjusts to students' interests, interests, learning styles, and readiness to learn in the learning process so that improved learning outcomes can be achieved [16]. Thus, differentiated learning can be said to be a learning model that suits the learning needs of students. In order to achieve student readiness and learning needs, there are 3 strategies for differentiated learning, namely: (1) Content differentiation, namely the provision of various learning materials and activities with various kinds of performance according to student needs; (2) Process differentiation, which is a way of providing learning that refers to learning styles and student needs; (3) Product differentiation, which is various forms of ways that students can expand and express their understanding [16]. By applying differentiated learning, students' mathematical abilities are expected to improve.

Mathematical skills are needed in the learning process to make it easier for students to solve existing problems not only problems in mathematics problems but also problems in everyday life. Students' mathematical abilities affect their reasoning abilities, students with high mathematical abilities are included in the category of students with excellent reasoning abilities, students with moderate mathematical abilities tend to have fairly good reasoning abilities, students with low mathematical abilities their reasoning abilities are classified as poor and the higher a person's mathematical ability, the higher the level of reasoning ability [17].

For this reason, the objectives of this study are: describe the application of differentiated learning models in the classroom, determine the mathematical reasoning ability of students who have high, medium, and low abilities in solving HOTS problems through differentiated learning models. Furthermore, the results of this study can be a reference and input so that students' reasoning abilities can improve by using learning models that are in accordance with the existing curriculum and learning can be achieved properly, can be a reference in understanding the extent of the level of reasoning of students' mathematical abilities in doing HOTS type problems and teachers can find out what problems students experience in doing these problems, can improve students' mathematical reasoning skills in doing HOTS type problems, can be a reference as a reference for differentiated learning model research.

2 Research Methods

This type of research is descriptive. Researchers conduct analysis only up to the level of description, that is, analyze and present facts systematically. The approach used is a qualitative approach. Research is carried out by analyzing and presenting facts systematically, the data from this study is in the form of facts that are presented in accordance with the reality that occurs in the research. The subject of his research was a Class VIII student of SMP Negeri 1 Sumbergempol. Researchers took subjects as many as 3 students, the selection of subjects was

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determined based on the results of the test of their mathematical ability in doing HOTS questions. Of the three students, one student has high mathematical reasoning ability, one student has medium mathematical reasoning ability, and one student has low mathematical reasoning ability.

The three research subjects had the following group limit criteria:

Table 1 Group Boundary Criteria

Groups	Boundaries
High	$x \geq (\bar{x} + SD)$
Medium	$(\bar{x} - SD) < x < (\bar{x} + SD)$
Low	$x \leq (\bar{x} - SD)$

Information:

x : Student math proficiency test scores
$\bar{x}$: average student grades
SD : Standard Deviation

Research instruments include observation sheets, questionnaires, test sheets, interview guidelines. Data collection techniques in this study are researchers making direct observations, giving questionnaires to students that must be filled in according to their respective opinions, giving test sheets in the form of HOTS description questions with Statistics material (Mean, Median, Mode) as many as 2 essay questions, and interviews to verify the data of the question description test results. Data is presented in the form of a brief description. From the results of the presentation of the data, analysis was carried out and then concluded to answer the formulation of the problem in this study. Conclusions must be drawn based on the results of data analysis derived from tests and interviews obtained when carrying out research in the field. In this study, the criteria for the formulation of the validity check of the data used are the degree of trust (credibility) and the data examination technique used is triangulation technique.

3 Results and Discussion

The results in the study are the results of data collected in the study, namely observational data, written tests and interviews that researchers conduct directly in the field. The following is an explanation of each research data:

A. Differentiated Learning Observation

The application of differentiated learning in the classroom is going well. The differentiated learning process was followed by all 32 students of grade VIII-K. Differentiated learning is carried out in accordance with the learning steps arranged in the teaching module. Before starting learning, researchers distributed learning style test questionnaire sheets to students with the results of 7 students with visual learning styles, 8 students with auditory learning styles, and 11 students with kinesthetic learning styles. Learning activities carried out according to the group of learning style test results.

In the learning process, researchers explain how to solve HOTS-type questions in Statistics material. At the end of the lesson, researchers distributed questionnaire sheets that must be filled out by each student. The questionnaire aims to find out students' opinions about differentiated learning.

Students think that differentiated learning is more exciting and interesting because they can learn and discuss together with friends who have the same learning style. This is in accordance with what was revealed in the research of [18], that differentiated learning is more interesting and can meet student learning needs that are tailored to student learning styles. Through the differentiated learning process, students can focus more on listening and understanding the explanation from the teacher on how to solve HOTS problems. So that when the teacher gives HOTS-type questions, students can do the questions independently, it can be seen from the process of students in doing the questions, students can determine what information is in the questions. Restu stated that differentiated learning tailored to the needs of student learning styles makes students able to follow the learning process easily and enjoyably [19]. This can improve students' reasoning ability in doing HOTS questions.

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B. Mathematical Reasoning Ability of Grade VIII Students with High Reasoning Ability Level

Answers of subjects with a high level of reasoning in solving HOTS questions:

1. The ability of students to present mathematical problems in the form of written statements

Question number 1:

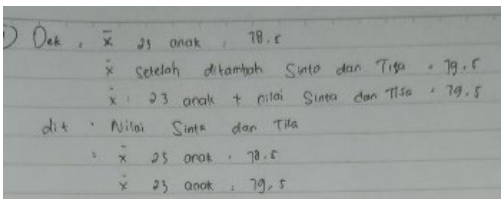

Figure 1. AUR answer to Question 1 with High Reasoning Ability in Presenting Math Problems

At this stage, the subject can mention the information obtained in question number 1. Subek can determine what is known and what is asked. As in question no. 1, subjects can write down the average scores of 21 students and 23 students. The subject can write down what the question asks, which is to find the value of Sinta and Tisa. This is in accordance with the results of the interview as follows:

Researchers : What information do you get from question number 1?
AUR : for number 1 that is known there is an average score of 23 and 25 children, then what is asked is proof that Tisa's value is greater than Sinta's value.

Question number 2:

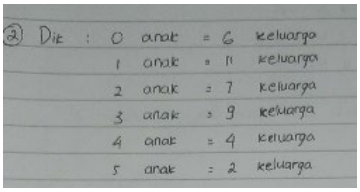

Figure 2. AUR Answer to Question 2 with High Reasoning Ability in Presenting Math Problems

In question number 2, the subject can mention what is known from the problem, such as turning a bar chart problem into a description where the subject can mention the number of children in each family. This is in accordance with the results of the interview as follows:

Researchers : What information do you get from question number 2?
AUR : If number 2 is known, there are many children in each family.

2. Students' ability to make guesses

Question number 1:

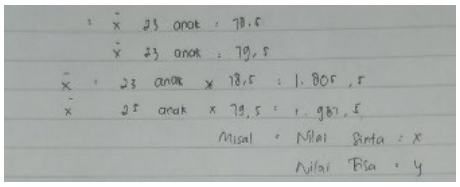

Figure 3. AUR answer to question 1 with High Reasoning Ability in Making Guesses

At this stage, the subject can make conjectures by converting the story problem into mathematical form. The subject can write down the mathematical form of what is known, i.e. suppose the value of sinta with "x" and the value of Tisa with "y". This is in accordance with the results of the interview as follows:

Researchers : Try to explain how you make guesses from number questions 1?
AUR : from question number 1 I use the symbol x for the value of Sinta and y for the value of Tisa. You see, the x and y symbols are usually often used.

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Question number 2:

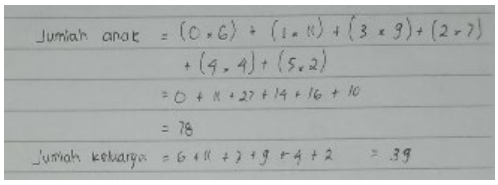

Figure 4. AUR Answer to Question 2 with High Reasoning Ability in Making Guesses

In question number 2, the subject can make guesses by converting the story problem into mathematical form. The subject can write down the number of children and the number of families by looking through a bar chart. This is in accordance with the results of the interview as follows:

Researchers : Try to explain how you make guesses from number questions 2?
AUR : The first one I will observe the bar chart first. Then I read one by one the number of each child in each family continued to be obtained.

3. Students' ability to manipulate mathematics.

Question number 1:

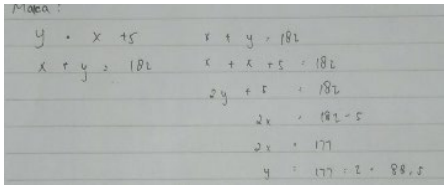

Figure 5. AUR Answer to Question 1 with High Reasoning Ability in Manipulating Mathematics

At this stage, the subject can find a formula/way to solve the problem correctly and precisely. The subject can write the formula used in solving the problem, namely the substitution and elimination formulas of y = x + 5 and x + y = 182. This is in accordance with the results of the interview as follows:

Researchers : How do you solve the problem?
AUR : For the number 1 to find the average sis, the total number of grades divided by the number of students right kak. Next, I use the formula rich in substitution and elimination.

Question number 2:

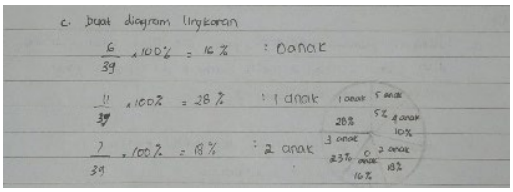

Figure 6. AUR Answer to Question 2 with High Reasoning Ability in Manipulating Mathematics

In question number 2, the subject can write the formula used in solving the problem, which is the formula in finding percentages to make a pie chart. This is in accordance with the results of the interview as follows:

Researchers : How do you solve the problem?
AUR : If number 2 (a) because you already know what is known so just multiply and add it, if number 2 (b) uses the average formula ( ), the number 2 (c) uses the percentage formula.

4. The ability of students to draw conclusions from the problem

Question number 1:

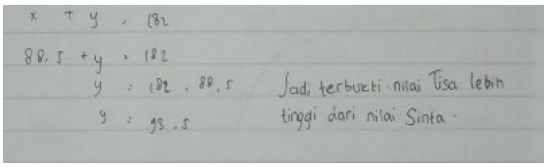

Figure 7. AUR Answer to Question 1 with High Reasoning Ability in Drawing Conclusions

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At this stage, the subject can write the conclusions from the results of solving the problem correctly and precisely. In question number 1, the subject can write proof that Tisa's score is higher than Sita's value. This is in accordance with the results of the interview as follows:

Researchers : From the answers you have worked on, what conclusions do you get?
AUR : for conclusion number one it can be proved that Tisa's value is higher than Sinta's value.

Question number 2:

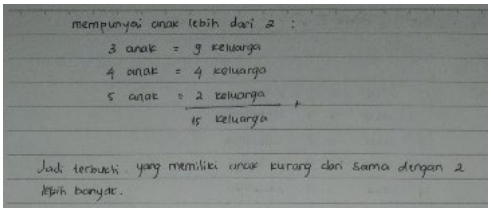

Figure 8. AUR Answer to Question 2 with High Reasoning Ability in Drawing Conclusions

In question number 2, the subject can write the conclusion of the results of solving the question correctly and precisely, that is, the subject can write evidence that families that have less than two children are more than families that have more than two children. This is in accordance with the results of the interview as follows:

Researchers : From the answers you have worked on, what conclusions do you get?
AUR : It can be concluded that families that have less than 2 more children equal 2 more.

C. Mathematical Reasoning Ability of Grade VIII Students with Medium Reasoning Ability Level

Answers of subjects with a moderate level of reasoning in solving HOTS questions:

1. The ability of students to present mathematical problems in the form of written statements

Question number 1:

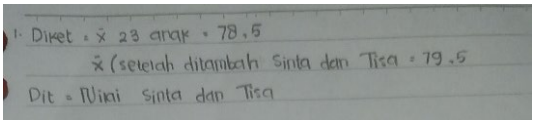

Figure 9. SA answer to question 1 with Medium Reasoning Ability in Presenting Math Problems

At this stage, the subject can write down any information obtained in the problem. The subject can write down what is known from the question, that is, the average score of 21 students and 23 students. The subject can also write what is asked from the question, namely proving that Tisa's score is higher than Sinta's value. This is in accordance with the results of the interview as follows:

Researchers : What information do you get from the number question 1?
SA : for number 1 that is known there is an average score of 23 children and 25 children kak, then what is asked is evidence that Tisa's score is higher.

Question number 2:

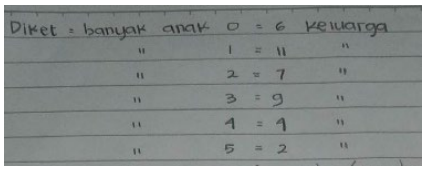

Figure 10. SA Answer to Question 2 with Medium Reasoning Ability in Presenting Math Problems

In questions number 1 and 2, the subject can mention what information is obtained in the question, namely the number of children in each family. This is in accordance with the results of the interview as follows:

Researchers : What information do you get from the number question 2?
SA : For number 2 which is known to many children in each family, then which (b) proves on average each family had 1 child, then (c) is asked to make a pie chart.

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2. Students' ability to make guesses

Question number 1:

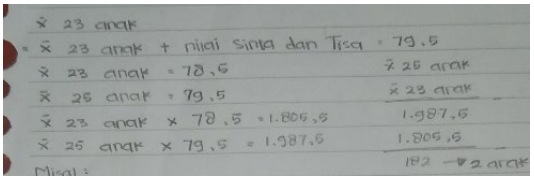

Figure 11. SA Answer to Question 1 with Medium Reasoning Ability in Making Guesses

At this stage, the subject can write down conjectures by converting the story problem into mathematical form. In question number 1 the subject can write the mathematical form of the problem, namely the subject for example the value of Sinta as "x" and the value of Tisa as "y'. This is in accordance with the results of the interview as follows:

Researchers : Try to explain how you make guesses from the problem?
SA : from the results known kak, so I suppose the symbol x for the value of Sinta and y for the value of Tisa.

Question number 2:

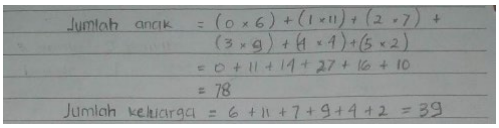

Figure 12. SA Answer to Question 2 with Medium Reasoning Ability in Making Guesses

In problem number 2, the subject can make guesses by changing the bar chart form problem to mathematical form. The subject can query the number of children and the number of families from a bar chart. This is in accordance with the results of the interview as follows:

Researchers : Try to explain how you make guesses from the problem?
SA : From the diagram, sis. Right from the digram can be seen the number of families that have children from 0 to 5 each how many families there are.

3. Students' ability to manipulate mathematics.

Question number 1:

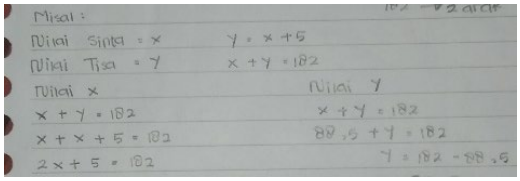

Figure 13. SA Answer to Question 1 with Medium Reasoning Ability in Manipulating Mathematics

At this stage, the subject can write a formula/way to solve the problem correctly and precisely. From the results of work number 1, the subject can write the formula used, namely the substitution and elimination formulas to find the x and y values. This is in accordance with the results of the interview as follows:

Researchers : How do you solve the problem?
SA : For the number 1, from what is already known, there are scores of 23 children and 25 children, then each of them does not multiply their grades, the scores of 25 students are reduced by the grades of 23 students.

Question number 2:

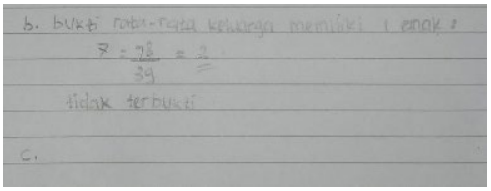

Figure 14. SA Answer to Question 2 with Medium Reasoning Ability in Manipulating Mathematics

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In question number 2 the subject has not been able to find a formula / way to solve the problem correctly and precisely, as evidenced by the incomplete work results. In question number 2 (c), the subject cannot solve the problem because he forgot the formula. This is in accordance with the results of the interview as follows:

Researchers : For number 2 how do you solve the problem?

SA : For number 2 (a) use the formula of multiplication and addition, if number 2 (b) use the average formula, number 2 (c) use the percentage formula which I am confused about how to do.

4. The ability of students to draw conclusions from the problem

Question number 1:

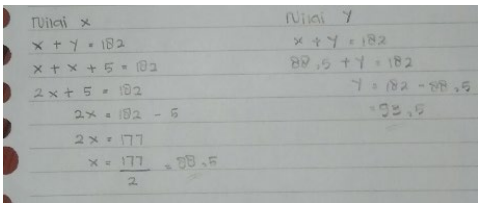

Figure 15. SA Answer to Question 1 with Medium Reasoning Ability in Drawing Conclusions

At this stage, the subject can write the conclusion of a particular question, namely question number 1. The subject can write the conclusion that Tisa's value is greater than Sinta's. Sinta's score is 88.5 and Tisa's score is 93.5. This is in accordance with the results of the interview as follows:

Researchers : From the answers you have worked on, what conclusions do you get?

SA : for number 1, the conclusion is that Tisa's score is higher than Sinta's score.

Question number 2:

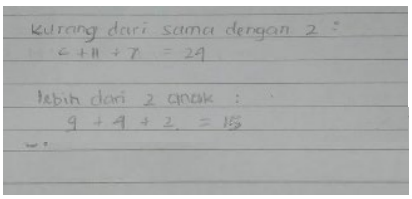

Figure 16. SA Answer to Question 2 with Medium Reasoning Ability in Drawing Conclusions

In question number 2, the subject has not been able to write conclusions from certain questions, for example in question number 2 (c) the subject cannot do because he does not know the formula. This is in accordance with the results of the interview as follows:

Researchers : From the answers you have worked on, what conclusions do you get?

SA : For number 2 (a) families that have less than 2 children more than 2, for which (b) the average family has 2 children, for which (c) cannot be.

D. Mathematical Reasoning Ability of Grade VIII Students with Low Reasoning Ability Level

Answers of subjects with a low level of reasoning in solving HOTS questions:

1. The ability of students to present mathematical problems in the form of written statements

Question number 1:

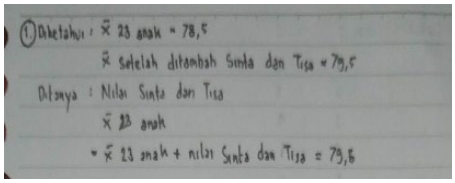

Figure 17. FA Answer to Question 1 with Low Reasoning Ability in Presenting Math Problems

At this stage, the subject can write down any information obtained in the problem. The subject can write down what is known from the question, that is, the average score of 21 students and 23 students. The subject can write down what is asked, namely evidence that Tisa's value is greater than Nisa's. This is in accordance with the results of the interview as follows:

Researchers : What information do you get from the number question 1?

FA : number 1 known average score of 23 children and 25 children, who were asked for evidence that Tisa's score was greater than Sinta's score.

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Question number 2:

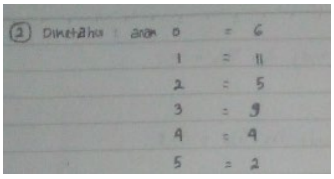

Figure 18. FA Answer to Question 1 with Low Reasoning Ability in Presenting Math Problems

In question number 2, the subject can mention any information obtained in the question. The subject can write down the number of children in each family as seen from the bar chart. This is in accordance with the results of the interview as follows:

Researchers : What information do you get from the number question 2?
FA : The question asked which (a) evidence of families having fewer than two children equals two, (b) evidence on average of each family having one child, (c) making a pie chart.

2. Students' ability to make guesses

Question number 1:

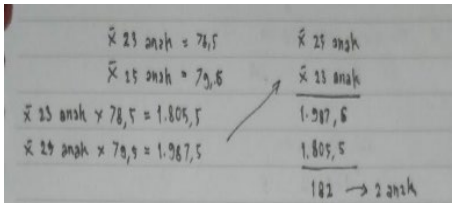

Figure 19. FA Answer to Question 1 with Low Reasoning Ability in Making Guesses

At this stage, the subject can write down conjectures by converting the story problem into mathematical form. It can be seen from the results of the work on question number 1, the subject can write the average symbol as x. This is in accordance with the results of the interview as follows:

Researchers : Try to explain how you make a guess solution to the number problem 1?
FA : Confused kak explain how, anyway the number one I know the average symbol.

Question number 2:

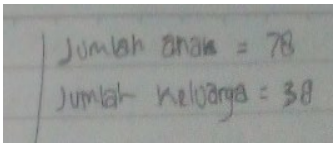

Figure 20. FA Answer to Question 2 with Low Reasoning Ability in Making Guesses

In question number 2, the subject can make guesses by converting the story problem into mathematical form, but in question number 2 students do not write how to get the results of the number of children and the number of families. This is in accordance with the results of the interview as follows:

Researchers : Try to explain how you make a guess solution to the number problem 2?
FA : confused kak explain how, number 2 I can't that (c).

4 Conclusion

Berdasarkan hasil dan pembahasan di atas, dapat disimpulkan bahwa penerapan pembelajaran Differentiation in the classroom goes well. Learning activities carried out in accordance with the group of learning style test results. At the end of the lesson, researchers distributed questionnaire sheets to students to find out what students think about differentiated learning. Through the differentiated learning process, students can focus more on listening and understanding the explanation from the teacher on how to solve HOTS problems. So that when the teacher gives HOTS-type questions, students can do the questions independently, it

can be seen from the process of students in doing the questions, students can determine what information is in the questions. This can improve students' reasoning ability in doing HOTS questions.

Subjects with a high level of mathematical ability in solving HOTS problems have met the four indicators of reasoning, namely, presenting mathematical problems in the form of written statements, this can be seen from the work of students who can find any information in the problem; making guesses, it can be seen from the answers of students who are able to find ways or formulas to solve problems; Manipulating mathematics, can be seen from the answers of students who are able to use a variety of different formulas that are linked in order to get the solution to the problem; and draw conclusions from the questions, can be seen from the answers of students who are able to write down the final results of the solutions done. While subjects with a moderate level of mathematical ability in solving HOTS problems only meet three reasoning indicators, except for the indicator of drawing conclusions. Subjects with low levels of mathematical ability in solving HOTS problems only meet two indicators of reasoning, namely students' ability to present mathematical problems in the form of statements and students' ability to make guesses.

Based on the results of research that has been done, there are several suggestions that can be given to schools should provide facilities that can be used to support differentiated learning activities, such as providing projectors in each class. Teachers can apply differentiated learning in learning according to students' interests and learning styles. Teachers are also expected to further hone students' mathematical skills by often providing HOTS-type questions to improve students' mathematical and reasoning skills. Students practice more often to do HOTS-type math problems that can hone their mathematical reasoning skills. Further researchers can develop steps of the differentiated learning process.

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