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Interference thinking in constructing students’ knowledge to solve mathematical problems

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Abstract. This research aims to describe interference thinking in constructing students’ knowledge to solve mathematical problems. Interference thinking in solving problems occurs when students have two concepts that interfere with each other’s concept. Construction of problem-solving can be traced using Piaget’s assimilation and accommodation framework, helping to know the students’ thinking structures in solving the problems. The method of this research was a qualitative method with case research strategy. The data in this research involving problem-solving result and transcripts of interviews about students’ errors in solving the problem. The results of this research focus only on the student who experience proactive interference, where student in solving a problem using old information to interfere with the ability to recall new information. The student who experience interference thinking in constructing their knowledge occurs when the students’ thinking structures in the assimilation and accommodation process are incomplete. However, after being given reflection to the student, then the students’ thinking process has reached equilibrium condition even though the result obtained remains wrong.

1. Introduction

Basically, the process of mathematical learning is closely related to the formation and using of thinking ability. This is due to the influence of 21st-century skills that require students to have the ability in understanding the concepts and improve high-quality thinking skills in analyzing the concepts, evaluating and finding alternative solutions to solving the problems [1]. In the same direction with the 21st-century skills, where each students must have metacognition that is used to refer to the awareness individuals have their own thinking, their evaluation that thinking, and their regulation of that thinking [2]. When students have been able to form their thinking, it allows students to have the ability to understand the concept to solve a problem.

While students in understanding a concept then they receive new information obtained from their brain works. The information will be processed to find a solution in justification that will be stored in the memory of brain. Furthermore, according to information processing theory which states that when information comes from the environment, then the information is processed temporarily (perceived), and puts into short-term memory, continued into long-term memory [3]. During the process of recalling information contained in the long-term memory, which is used to solve the problem in the short-term memory may occur interference or exchange of information. This form of interference is called interference thinking.

Interference thinking in solving problems occurs when student has a construction of two or more different concepts in which the two or more concepts are interrelated [4]. Meanwhile, interference refers to the lack of ability to recall information when it is similar to the one that stored in memory [5].
Interference thinking is an error that occurs because of the conception that interferes each other, so one concept disturbs or interferes another concept [6].

Rodieger et. al (2010) in their book discusses Mc Geoch's statement that forgetting comes from the results of memory error accessing information is divided into two forms, they are due to proactive interference and retroactive interference [7]. Proactive interference is old information interfering with the ability to remember new information. Meanwhile, retroactive interference is new information interfering with the ability to remember old information [8].

Problems that can cause interference thinking in mathematics quite a lot, among others: the comparison of value and reversed values, Least Common Multiple (LCM) and Greatest Common Divisor (GCD), angular and contradictory, permutations and combinations, and so forth [4,6]. However, in this research, the problem that can cause interference thinking is the sequence and series.

Based on research, interference output occurs when two categories are tested separately rather than tested together [9]. This is in accordance with the case of students in this research, ie students are not only difficult to distinguish the problems done using sequences and arithmetic series but also sequences and geometry series when displayed together. Whereas for solving sequence and arithmetic series problems with sequences and geometry series are different, arithmetic sequences have a distinction denoted by b and the difference between fixed rates, whereas the geometric sequences have a ratio denoted by r and the value of comparison between indefinite tribes [10].

Less optimal problem-solving in learning mathematical and instructional emphasis on procedures, resulting in errors in the construction of mathematical problem-solving [11]. Problem-solving is a major part of learning math. Problem-solving skills can be transferred to solve other problems in life [12]. The importance of developing problem-solving in mathematical learning is expressed by NCTM which states that “solving the problems is not only a goal of learning mathematical but also a major means of doing so... By learning to problem-solving in mathematical, the student should acquire ways of thinking, habits of persistence and curiosity, and confidence in an unfamiliar situation” [13]. Meanwhile, according to Polya problem-solving is interpreted as an attempt to find a way out from a difficulty in order to achieve a goal that is not immediately achievable [6].

Construction of problem-solving depends on the construction of mathematical concepts experienced. Good concept construction on students will help to simplify the process of problem-solving construction [4]. It can be traced using Piaget's assimilation and accommodation framework, helping to know the student thinking structures in solving the problems.

The assimilation process is the process of integrating new stimulus into the scheme that has been formed. The accommodation process is a process of integrating the new stimulus through the modification of the old scheme or through the formation of a new scheme to adapt to the newly acquired stimulus [14]. The balance between assimilation and accommodation are called state of equilibrium and disequilibrium occurs when the child is in a new environmental phenomenon that is incompatible with the child's mental scheme [15].

The analytical process of assimilation and accommodation has been illustrated by Subanji and Supratman [14]. So it can help to understand the two forms of assimilation and accommodation processes.
Means the suitability of a problem structure with the structure of thinking
Means the mismatch of structure of a with the structure of thinking

Figure 1. Assimilation and Accommodation Process (Adapted Subanji and Supratman, 2015)

In the process of solving the problem, when students are faced with a construction of two concepts in which the structure of thinking the student has no scheme in accordance with the problems it faces the interference will occur thinking. This is due to the similarity between the two concepts that interfere with each other. Therefore, this research will describe the process of interference thinking in solving the problem of sequence and arithmetic series with sequences and geometry series based on assimilation and accommodation framework.

2. Research Methods
The method of this research was a qualitative method with case research strategy. The qualitative research is aimed to uncover a problem and develop it in detail to understand the central phenomenon of a problem [16]. Subjects in this research involving 28 students of 9th grade in Junior High School Al-Islam 1 Surakarta that were selected by purposive sampling. Those data were analyzed descriptively using Miles and Huberman steps.

The data in this research involves the result of solving the problem of students’ interference test and interviews transcripts about students’ errors in solving the problem. This interview was conducted to trace the causes of students’ interference thinking in solving the problem. The interview was a semi-structured interview. The focus of the research was to analyze the interference of students’ thinking in solving the sequence and series problem based on assimilation and accommodation framework from Piaget’s. However, this study will only describe students who have only proactive interference.

3. Results and Discussion
Results and discussion obtained by researcher can trace the process of interference thinking in solving the problem of sequence and series. The tests were conducted on 28 of 9th-grade junior high school students and the results of classification of interference thinking will be presented in Table 1 as follow.

| Type of Interference | Students |
|----------------------|----------|
| Proactive            | 7        |
| Retroactive          | 3        |

Based on Table 1, it was found that the classification of students’ thinking interference has two types of interference, namely proactive interference and retroactive interference. But, this research focused on students who have only proactive interference. Therefore, Subject (S) was chosen to be a
research subject that represented proactive interference. Moreover, the problem related to geometric sequences for proactive thinking interference are as follows:

A car has been purchased for Rp. 80.000.000,00. The selling value becomes ¾ of the previous price every year. What is the sale value of the car after 3 years of use?

The following will be presented on the answers of students who experience proactive interference on the matter of sequence and series. When the student has given a matter of geometry sequence, but at the time of answering the question, the student responded by using an arithmetic sequence formula. The result of the student work is shown in Figure 2 below.

Based on Figure 2 above, interference test results show that the student solves the geometry sequence with the completion of the arithmetic sequence. At the beginning of the construction process of her knowledge, S writes the known and asked questions. After that, S states that the question is a matter of arithmetic sequence with reasons $U_1 = 80.000.000$ and difference $(b) = \frac{3}{4}$. For the first problem ($P_1$), the student assumed that $\frac{3}{4}$ is the difference. Furthermore, for the second problem ($P_2$), the student assumed that formula $U_n = a + (n - 1)b$ is the right solution to solve the problem. Therefore, S searched for the 3rd term by using the formula $U_n = a + (n - 1)b$. Having obtained the calculation of the 3rd term, S determined the value of $U_3$ for 14.000.000.

The researcher conducted interviews to find out more in the process of work S. Interviews show that S considered important information on the matter is the selling value to 3/4 of the previous price every year. According to her, 3/4 is the difference so that the selling price per year is fixed. In addition, students considered other important information is the asking price after 3 years of use. From the information known and asked, S could determine the solution to the problem by using arithmetic sequence. Below will show interview conversation as follows.

**Researcher**: From that question, what information is obtained?
**Subject**: Hmm.. That, miss (Students pointed toward the question)
**Researcher**: Please, pay attention back to the question.
**Subject**: This is, miss. A car has been purchased for Rp. 80.000.000,00. It means, the purchase price of his car is Rp. 80.000.000,00 (Student mumbling)
**Researcher**: What’s next?
**Subject**: The selling value becomes ¾ of the previous price every year.
**Researcher**: Next?
**Subject**: Continue.. What is the sale value of the car after 3 years use?.

Based on the dialogue above, after the student obtains the information data and information questions, it makes it easier for the student to understand the problem. Furthermore, the interview was continued to find out how the students drafted the settlement plan on the question as follows.
Researcher : After you got the information, what's steps do you take?
Subject : From the question, I can find out that \( a = 80.000.000 \).
Researcher : What is called \( a \)?
Subject : \( a \) is the beginning, the first term, miss.
Researcher : Looking for the difference, miss. Because the sale value becomes \( \frac{3}{4} \) from the previous price. So. \( \frac{3}{4} \) it is the difference, miss.
Researcher : Why do you call \( \frac{3}{4} \) the difference?
Subject : Yes, It is because each year the selling value is constant, miss. As I recall, if it is constant, it calls difference. But, I also forget miss. (Students smile and look confused)
Researcher : How should it be?
Subject : Hmm.. Is it the ratio, miss? (Students look confused between the difference and the ratio)
Researcher : What is the ratio?
Subject : The ratio is not fixed value, miss.
Researcher : Then, what is the different between the ratio and the difference (b)?
Subject : As I far as I know, the ratio is multiplication and the difference is a sum, miss.
Researcher : What does it mean?
Subject : Yaa.. The ratio is the value of each tribe multiplied, but if the difference is the value of each tribe summed, miss. (Students are hesitant in answering and looking up while recalling)
Researcher : So, \( \frac{3}{4} \) what is it?
Subject : The difference is, miss.

From the dialogue, it appears that the subject is very confident with the answer that the answer is correct. In the conversation above, the student is indicated to experience interference thinking. As Subanj has pointed out that interference thinking occurs when the student has a construction of two or more different concepts in which the two or more concepts are interrelated [4]. When S preparing a problem-solving plan, student seems to forget in determining \( \frac{3}{4} \). The existence of error about the construction of the concept experienced by student causes the student could not distinguish between the ratio with a difference, so that arithmetic sequence concept interferes geometry sequence concept. Researchers continued the dialogue with the student by providing a trick question that leads to conflict cognitive.

Researcher : After that, what else should you do?
Subject : Hmm, the value of a same \( b \) already existed, after that continued to \( U_3 \), miss. So I was using arithmetic.
Researcher : What is your reason for using an arithmetic sequence? Do you know the formula for arithmetic sequences?
Subject : As I recall that the difference must be using arithmetic, miss. (Student smiling). Then, I was looking for the answer with the formula \( U_n = a + (n - 1) b \). Next, continued to include \( a = 80.000.000 \) and \( b = \frac{3}{4} \). After I counted, the result was 14.000.000.
Researcher : Are you sure about your answer?
Subject : Hmm.. Not really, miss (Students shook her heads and looked down)
Researcher : Why are you unsure of the answers you get?
Subject : Actually I am still confused must use difference or ratio, miss.
Researcher : Can you use information to rework it in a different way?
Subject : (pause for a moment) May I try again, miss?
Researcher : Yes, please.
Prior to the interview, the results of the analysis of interference thinking experienced by S based on the assimilation and accommodation framework show that when S faced a problem, S actually had a scheme related to the sequence and series problem. This shows the students’ thinking structure occurs assimilation process. However S used the arithmetic sequence scheme into the geometry sequence, so the answer is not appropriate. The student's thinking structure before being given a reflection in solving the geometry sequence problem and assuming the settlement using the arithmetic sequence is presented in the diagram flow as follows.

![Diagram 1. Students’ Construction Process Who Experience Thinking Interference Before Reflection](image)

Information:
- As : Assimilation Process
- Eq : Equilibrium Process

Based on Diagram 1 above, it appears that when students are faced with a problem about the geometry sequence, the student obtains the data information and the question information. However, as the student construction her knowledge to solving the problem, the assimilation process dominates her thinking space. Assimilation occurs when S knows that "The selling value becomes \( \frac{3}{4} \) of the previous price every year". Meanwhile, S considers that if every year the sale value of the car becomes \( \frac{3}{4} \) from the previous price then \( \frac{3}{4} \) is a difference value always fixed. Regardless of the prior information and questions were given, S determines that if the values of a and b are known in solving the problem, the next step is to use the arithmetic sequence formula to solving the problem. After the
calculation by S then obtained the result \( U_3 = 14,000,000 \) and this signifies when doing the test results obtained to reach disequilibrium conditions. This means S uses assimilation as the process of thinking.

After the interview, the student thinking process in solving the problem was still at the assimilation stage. However, when S was asked again "Why is \( \frac{3}{4} \) called difference?" and S responded with doubt whether it is a ratio. The question was asked, "What is different of ratio with a difference (b)?". This suggests that when S thinks back to different in ratios and differences (b), it means that in the students’ thinking process, S experiences accommodation process and occur the interference of thinking. Thus, S interprets the arithmetic sequence scheme into a geometry sequence. Once given a new stimulus, then the thinking process S arises the state wants to try to resolve the problem.

In the process of problem-solving, students are faced with challenges that arouse curiosity to solve them. The curiosity indicates an imbalance between assimilation and accommodation process called disequilibrium [4]. Therefore, the student thinking process continued on accommodation process, where student modified the old scheme to form a new stimulus. The following will show the results of the work S when doing reflection on the problems encountered.

**Figure 3.** The result of student work reflection

Based on Figure 3 the results of student work reflection can be analyzed further using student's thinking structure in solving the problem of geometry sequence. The structure of students' thinking interference after being given a reflection as follows.

**Diagram 2.** Interference thinking Structure After Reflection
Based on Figure 3, when a student rewrites her work, the thinking process begins again through the assimilation process with the view that if each year the car's sale value becomes $\frac{3}{4}$ from the previous price, then $\frac{3}{4}$ is a ratio whose value is not fixed. After knowing the first tribe (a) and the ratio, the student uses a geometry sequence formula to solve the problem it faces. It indicates that the accommodation process is in progress. Furthermore, students’ thinking interference after reflection shows that the error occurs when the student determines the value of $n$ of the tribe so that at the time of calculating the students’ answer had not the correct answer, i.e., $U_3$ is 45,000,000.

After reflection of the students’ thinking process, it has reached equilibrium because of the balance between assimilation and accommodation processes, but the result obtained is still wrong. This is in line with Black and Pope (2008) who stated that the balance between assimilation and accommodation are called state of equilibrium [15]. Then, research conducted by Sukoriyanto et al. (2016) also stated that the real global interference is global interference if it continued with reflection, the answer is still wrong [6]. Therefore, it can be said that the student who experiences proactive interference is caused by interpreting the arithmetic sequence as a geometry sequence and while the reflection results obtained is still wrong even though it has reached an equilibrium condition.

4. Conclusion
In this research, the occurrence of interference thinking in the student is characterized by the student interpreting the concept of sequence and arithmetic series as a sequence and geometry series. The interference experienced by the student in sequence and series is proactive interference because the students’ memory of the sequence and the arithmetic series dominates the thinking space. Moreover, when a student constructs her knowledge, the student also constructs what problems faced her. Construction of problem-solving has been using Piaget's assimilation and accommodation framework, thus it can help to know the student thinking structures in solving the problems. Construction of problem-solving depends on the construction of mathematical concepts experienced. Before reflecting on the answer, the student experiences a thinking process of assimilation and accommodation are incomplete. In other words, the concept of arithmetic sequences interferes with the concept of geometry sequence. However, when reflected on the answer, the student reaches equilibrium condition, where there is a balance between the assimilation and the accommodation process even though the final result obtained still wrong after the reflection.

As an implication of these findings, once the teacher knows what the possible interference occurrences happen to the student, the teacher can design the lesson according to the sequence and series material. Therefore, teachers should emphasize an understanding of the context of the problem that has been given about the differences between the two types of sequences and series with the aim that students can make clearer memories of both materials and no matter more dominates the students’ thinking space. In addition, teachers should direct students to have metacognition that is used to shape student self-awareness, so that students have the ability to understand concepts, improve thinking skills that trigger to develop critical thinking and creative thinking skills in analyzing and looking for alternative solutions to problems encountered.

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