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Student's Thinking Process in Solving Proportions Based on Information Processing Theory

Isman M. Nur[1], Cholis Sa'dijah[2*], Santi Irawati[3], Subanji[4]

[1,2,3,4] Mathematics Education Department, Universitas Negeri Malang, Jalan. Semarang No. 5, Malang, 65145, Indonesia

Abstract

This study aims to analyze and to describe, in terms of information processing theory, the thinking processes of junior high school students as they solved problems involving direct and inverse proportions. This study design is qualitative and exploratory-descriptive in nature. 26 students in the seventh grade of SMP Negeri 1 Kota Ternate were assigned direct and inverse proportion assignments. Eventually, based on the students' thinking potential and verbal and written communication skills, 3 students who could describe the thinking process based on information processing theory components were selected. The instruments for data collection consisted of questions on direct and inverse proportions, supported by interview procedures. Based on the analysis and discussion of research results, three categories of student thinking processes can be identified: (1) multiple thinking categories in solving direct proportion problems, which occur in the perception component when S1 students write or express problem solving plans using multiple strategies to process accepted information; (2) the multiplication thinking category in solving inverse proportion problems, which occurs in the perception component; and (3) the generalization thinking category in solving inverse proportion problems, which occurs in the perception component.

Keywords: Thinking process, proportion, problem solving, information processing theory.

Introduction

Thinking in solving problems is one of the most important goals in learning mathematics (Jaleel & Titus, 2016; Nepal, 2017; Li, et al., 2019). Mathematical thinking plays a crucial role in learning activities and also in everyday life. According to (Bakar, 2015), mathematical thinking is an important aspect for students as it helps the brain to understand and remember the subject matter. Learning is not only carried out through listening to the material, writing the material, and doing tasks but also by involving mental processes that occur in the brain. Therefore, learning can refer to an activity that is always related to individual thought processes or cognitive processes (Walle, 2007).

Mathematical thinking can be seen as a way of understanding mathematical problems based on the various sources collected to study a mathematical object (Mustafa, et al., 2019). Thinking, according to (Bakar, 2015), is an activity in which the mind is used to make decisions, find meaning, make judgments, and solve problems based on information and experiences found in everyday life. One way to find out students' thinking processes is to give them problems. In line with the opinion of (Solso, et al., 2008), someone will be motivated to think if they are faced with a problem. (Subanji, 2013), argues that an important key for students to think is to involve them in questions that force them to take advantage of their ideas to solve problems. When students solve problems, students are encouraged to think and try to find the solutions.

The ability to solve problems is the ultimate goal of mathematics learning (Ersoy, 2016; Evidiasari, et al., 2019; Puran, et al., 2017). Solving problems in mathematics is considered very helpful for students' success in learning mathematics. (Hidajat, et al., 2019), state that mathematical problems are necessary for the development of mathematics itself. Therefore, students' ability to solve problems should be developed in mathematics classrooms.

Problem-solving is a method used by students to understand and solve a problem (Sriraman, 2003). In problem-solving, students are required to develop the ability to create new ideas regarding the problems they face. As stated by (Santrock, 2008), problem-solving involves finding a suitable way to achieve a goal. When students formulate a problem, solve a problem, or want to understand a problem, they do thinking activities. (Solso, et al., 2008), define problem-solving as an ability to think that is directed directly to find a solution to a specific problem. Problem-solving and thinking are two interconnected activities (Cavanagh & McMaster, 2017). As explained by (Saragih & Napitupulu, 2015), when solving a problem, students carry out a series of thought processes.

Corresponding Author e-mail: xxxxxx

https://orcid.org/xxxx-xxxx-xxxx-xxxx

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In this study, the thinking processes carried out by the participants in solving mathematical problems include the thinking process involved in understanding a problem, developing a problem, determining the problem-solving strategy, and calculating the numbers.

One of the math problems related to students' thinking processes is the proportion (Pitta-Pantazi & Christou, 2011; Sapti, 2015). Proportion is a basic concept for understanding various mathematical topics (Dougherty, et al., 2016). The concept of proportion is covered by the entire curriculum from primary to secondary school, highly useful for various professions in everyday contexts (Frith & Lloyd, 2016). In the school curriculum, the concept of proportion is used in solving problems. Various topics in mathematics learning in schools, such as probability, trigonometry, plane geometry, fractions, algebra, require knowledge of proportions (Ojose, 2015). In addition, the proportion is also expressed as part of a multiplicative conceptual interrelated with many mathematical concepts, such as scale, recipe ingredients, price comparisons, value for money, number of children, and speed (Cetin & Ertekin, 2011; Beckmann & Izsák, 2015). Students who can identify such multiplicative relationships are said to have multiplicative thinking skills and are usually capable to solve proportions correctly (Chaim, et al., 2012).

Direct and inverse proportions are part of the proportion relationship. In line with the opinion of (Chaim, et al., 2012), the direct proportion is the two quantities formed when quantitative changes occur uniformly, meaning that the quantity a is multiplied by factor m; henceforth, quantity b must be multiplied by m (m is the constant factor). They further argue that the inverse of proportion is the formation of two quantities when quantitative change occurs uniformly but in an opposite direction, for instance, quantity a is multiplied by factor m then quantity b must be divided by m (m is the constant factor). Mathematically, the relationship between proportions can be represented in $a/b = c/d$ (direct proportion) and $a/b = d/c$ (inverse proportion) (Chaim, et al., 2012). In algebra, direct proportion and inverse proportion are stated in the following formulas $y = m \bullet x$ and $x \bullet y = m$, where m is the constant (Beckmann & Izsák, 2015). The difference between these two proportions is indicated by the direction of change, whether it is the same or the opposite (Johar & Yusniarti, 2018). In addition, direct proportion and inverse proportion have characteristics and keywords that differentiate one another.

Students tend to have difficulty distinguishing direct and inverse proportions. (Pelen & Artut, 2016), conducted a study of 331 seventh-grade students and found that some students have difficulty distinguishing direct and inverse proportions. In addition (Boyer, et al., 2008) observed that the majority of students have difficulty solving the problem of direct proportions and inverse proportions. Research conducted by. According to (Sukoriyanto, et al., 2016), students are more likely to make errors in proportions due to similarities in the two problem structures. The similarity of two problem structures is two materials with an adjacent presentation to each other but have no mutual requirements.

Research on proportion has been carried out before, but the type of problem used is the missing value problem (direct proportion) (Steinthorsdottir & Sriraman, 2009; Cetin & Ertekin, 2011; Tjoe & Torre, 2014; Ojose, 2015). The types of problems studied by (Silvestre & Ponte, 2012; Livy & Herbert, 2013), are the missing value problem (direct proportion) and comparison problem. Therefore, due to the large number of previous studies that examined direct proportion, this study examines students' thought processes in solving direct proportions and inverse proportions.

Up to recently, there has been no research reporting the thinking process of students in solving direct proportions and inverse proportions based on the information processing theory. Based on previous research, we came up with a research plan that focuses on students' thought processes in solving direct proportions and inverse proportions. Research related to proportions has been conducted by previous researchers, such as (Silvestre & Ponte, 2012), who examine the thinking process of sixth-grade students on missing value problems (direct proportions) and comparison problems. In addition, (Sumarto, et al., 2013), investigate how fourth-graders used intuitive understanding in solving comparison problems. However, this study uses a different type of problem from past studies. Besides, the research subjects used in the previous study were elementary school students, but this study focuses on the thinking process of secondary school students in solving direct proportions and inverse proportions. According to (Bayazit, 2013), the process of solving mathematical problems should be investigated based on students' thinking processes. If students' thinking processes can be identified, then their mistakes can be recognized. The teacher plays an important role in supporting the development of students' mathematical thinking (Sapti, et al., 2019).

Students' thinking processes in solving direct proportions and inverse proportions can be analyzed using information processing theory. (Solso, et al., 2008), defines information processing theory as a cognitive learning theory that describes the processing, storage, and recall of knowledge from the brain or mind. Information processing theory is closely related to students' thought processes in solving problems. Each student has a different way of collecting, organizing, and processing the information applied to solve problems (Rozencwajg & Corroyer, 2005). The information processing theory has two main components, namely a component of information storage and cognitive processes (Slavin, 2006), that work complementary.

According to (Slavin, 2006), information is stored in (1) sensory register which is the first storage place for large amounts of information obtained from each sense; (2) short-term memory, where a limited amount of information is processed and loaded for a few seconds; (3) long-term memory, which is a part of a memory system that stores information permanently and has a very large capacity. However, (Santrock, 2008), argue that the components of the cognitive process consist of 1) attention, the concentration of the active mind on certain information by eliminating other information; 2) perception, an individual's interpretation of the information received; 3) rehearsal, the repetition of information in the mind that increases its storage; 4) encoding, the process of entering information into long-term memory; 5) retrieval, the retrieval of information from memory stores. These components are designed to help understand the schema of students' thinking

processes occurring in their minds. The thought process plays an important role in helping students solve mathematical problems. When students solve math problems, especially direct proportions, and inverse proportions, students think and try to find solutions to these problems, as one of the main goals in learning mathematics is to be able to think to solve mathematical problems. This study aims to examine the thinking process of junior high school students in solving the problem of proportion and inverse comparison based on information processing theory.

METHOD

Research Design

Using the concept of information processing, this research aims to describe the students' thinking process when solving problems involving direct and inverse proportions. It is this in-depth disclosure of students' thinking processes that is the focus of this research. This study design is qualitative and exploratory-descriptive in nature. The characteristics of the qualitative research conducted in this study are based on (Creswell, 2012): (1) natural, namely having actual settings, such as direct data sources and researchers are the key instruments. The researcher is a key instrument meaning that it is better able to capture and describe the thinking processes carried out by students. (2) the data is descriptive, namely verbal or written data obtained from observation analysis, answer sheets, and interviews with the subject. (3) paying attention to the process, namely emphasizing the process more than the results.

Participants

The researchers asked 26 seventh-grade students of SMP Negeri 1 Kota Ternate, Indonesia, questions about direct and inverse proportions. 12 students answered questions about direct proportions entirely, whereas 14 students answered incompletely. Since the questions included the inverse of proportion, only 10 students provided complete answers, while 16 provided incomplete answers. The students who correctly answered questions about direct and inverse proportions were then chosen based on their mental skills and verbal and written communication skills. Ultimately, three students who could articulate the thought process based on the components of information processing theory were identified. Table 1 shows the results of selecting subjects for each category.

Table 1: Categories of research subjects

Number of subjects	Number of subjects per category		
	Multiple thinking category	Multiplication thinking category	Thinking interference category
3 subjects	1 subject (S1)	1 subject (S2)	1 subject (S3)

One subject was presented for the category of multiple thinking, one subject was presented for the category of multiplication thinking, and one subject was presented for the category of thinking interference. S1 subject was chosen to be presented and examined based on their data from the category of multiple-thinking subjects. Subjects in the area of multiplication thinking were chosen to have their data presented and analyzed; they were then classified as S2 subject. The topic from the category of thought interference that was chosen to be presented and evaluated for the data was designated as the S3 subject. Repeated or continuous subject selection until data saturation is achieved. Data saturation refers to the situation in which the subjects for each category have the same or a set pattern across several research subjects.

Data Collection

The instrument used to reveal the participants' thought processes in solving direct and inverse proportions were equipped with supporting instruments in the form of test questions and interview guidelines. The test questions were developed to reveal students' thought processes in solving direct proportion and inverse proportion. The test questions were used as the main instrument to reveal the participants' thought processes, while the interview guide was used as a supporting instrument. Data mining through interviews was carried out by combining structured and unstructured interview questions. A structured interview is an interview in which the interviewer determines his problems and questions asked to gather answers for the assumptions. In order to find non-standard information and to delve deeper into a problem by emphasizing irregularities, unusual interpretations, reinterpretations, or new approaches, unstructured interviews were conducted. In the unstructured interviews, the questions were not arranged in advance but were adjusted to the circumstances and unique characteristics of the respondent.

Data Analysis

This study's data analysis is based on information processing components that may be employed to reveal how students solve direct and inverse proportion problems. The components of information processing can be presented in Table 2.

Table 2: Student Thinking Processes Based on Information Processing Components

Information processing component	Description
Sensory recording	This memory system gets a large amount of information from the senses and stores it for a short period of time.
Attention	Students focus on reading the questions completely and writing down or saying what they know and what is being asked about the questions.

Perception	Students write or express problem-solving strategies employing information-processing processes.
Rehearsal	Students repeat the problem by rewriting the previously provided material.
Retrieval	The process of information retrieval from long-term memory that is required for processing in short-term memory.
Encoding	Students explain each completed step and then draw a conclusion based on the results.

FINDINGS

The students' thinking processes in solving the problem of direct proportions and inverse proportions based on components of information processing theory found three categories of thinking processes, namely (1) multiple thinking categories, (2) multiplication thinking categories, and (3) thinking interference categories. Of the three categories of thinking processes occur in the perception component, where students express plans for solving problems using different strategies that can be used to process the information received. The categories of students' thinking in solving direct and inverse proportion problems can be presented in Figure 1 below.

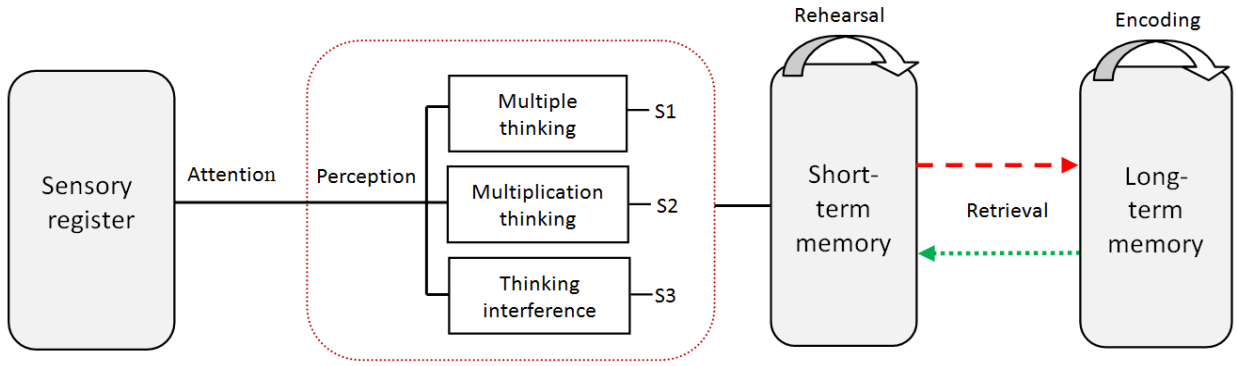

Figure 1: Categories of Student Thinking Processes in Completing Problems of Direct Proportions and Inverse Proportions

The first finding, namely the multiple thinking category acquired by S1 subject, will be referred to as a multiple thinking category subject in answering direct proportion problems. The second finding, namely the category of multiplication thought acquired by S2 subject, will be referred to as a subject in the category of multiplication thought while addressing inverse proportion problems. The third finding, namely the interference of thought acquired by the S3 subject, will be referred to as a member of the category of interference of thought in solving the inverse proportion problem. The thought processes of the three subjects for each category are not random, but are based on field notes and each subject's effort in answering direct and inverse proportion problems. Three categories of student thinking processes were found, which can be shown in Table 3 below.

Table 3: Student Thinking Process Categories in Solving Direct Proportion and Inverse Proportion Problems

Subject	Thinking Process Category	Description
S1	Multiple thinking	Student expresses or writes plans to solve problems in direct proportion utilizing multiple strategies to interpret acquired information as part of the perceptual component.
S2	Multiplication thinking	Student expresses or writes plans for resolving the inverse proportion problem using a multiplication strategy to process the incoming information during the perceptual component.
S3	Thinking interference	Students expresses or writes plans for addressing problems related to the inverse proportion formula but are solved using the direct proportion formula.

Data Exposure and Analysis of the Occurrence of Multiple Thinking Processes

S1 subject is exposed to different thinking categories. Interview data, field notes, and subject response sheets can be used to show multiple-thinking data while answering direct proportion problems.

(S1) Subject Thinking Process Description

Using the components of information processing theory, one may analyze the description of the S1 subject's thinking processes. Sensory recording, attention, perception, rehearsal, retrieval, and encoding are the components of information processing theory. When direct proportion questions were presented, S1 students watched and read the questions. Subject S1 stores information after reading the questions in sensory recordings. The thought process of the S1 subject is shown in Figure 2.

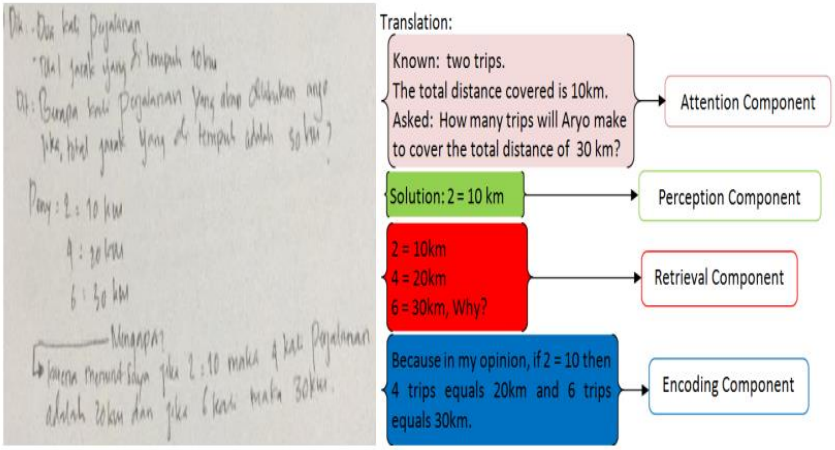

Figure 2: S1 subject's thinking process in multiple categories

The following interview results demonstrate the occurrence of the S1 subject's thinking process about the problem of direct proportions. The results of the S1 Subject Interview in Table 4 below.

Table 4: Interview Results of S1 Subjects

Researcher	:	From the questions you just read, do you understand?
S1	:	Yes, I so, sir.
Researcher	:	From this question, what do you understand?
S1	:	I think it's about direct proportion
Researcher	:	What do you think what is known about it?
S1	:	It is known that two trips with a total distance traveled are 10 km
Researcher	:	Then, what is asked in the question?
S1	:	How many trips if the total distance traveled is 30 km
Researcher	:	Ok, then how do you plan to solve this problem?
S1	:	To solve this problem, I prove by multiplying by five
Researcher	:	Is there any other way?
S1	:	This is the only way I understand sir!
Researcher	:	Furthermore, why is it written that 2 equals 10, 4 equals 20, and 6 equals 30?
S1	:	Yes, I multiplied it by 5. Because, 2 times 5 equals 10, 4 times 5 equals 20, and 6 times 5 equals 30.
Researcher	:	The results of the work you get from the first step to finding the result, your conclusion What?
S1	:	So, my conclusion in solving this problem is that the distance traveled as far as 30 km is 6 laps.

Attention is the focus on the obtained information by expressing what is known and what is asked in the problem. S1 subject recognizes that two trips with a total distance of 10 km are known in the problem. In addition, the problem asks how many times the trip is completed if the total distance traveled is 30 kilometers. Perception comes after the results of attention, information obtained as a strategy that may be utilized to achieve the correct problem-solving. S1 subject revealed that each round can be multiplied by 5 to get the number of rounds required to cover 30 kilometers. The retrieval of information from long-term memory is subsequently transferred to short-term memory for processing. S1 subject is able to record two trips of 10 km, four trips of 20 km, and six trips of 30 kilometers. The concept of direct proportion is stored effectively in long-term memory, allowing for the calculation of six trips over a distance of 30 kilometers.

Data Exposure and Analysis of the Occurrence of Multiplication Thinking Processes

Subject offered in the category for multiplication thinking is S2 subject. In order to solve the inverse proportion problem, interview data, field notes, and subject answer sheets can be used to provide multiplication thinking data.

(S2) Subject Thinking Process Description

The description of the thinking process of S2 subject was analyzed based on the components of information processing theory. The components of information processing theory involve attention, perception, rehearsal, retrieval, and encoding. When questions related to the inverse of this proportion are given, S2 subject observes and reads the questions given. After reading the questions, then storing the information into sensory recordings through the senses. Because sensory recordings are the outer storage areas that directly capture information or directly deal with the

information provided. The thinking process of S2 subject can be shown in Figure 3 below.

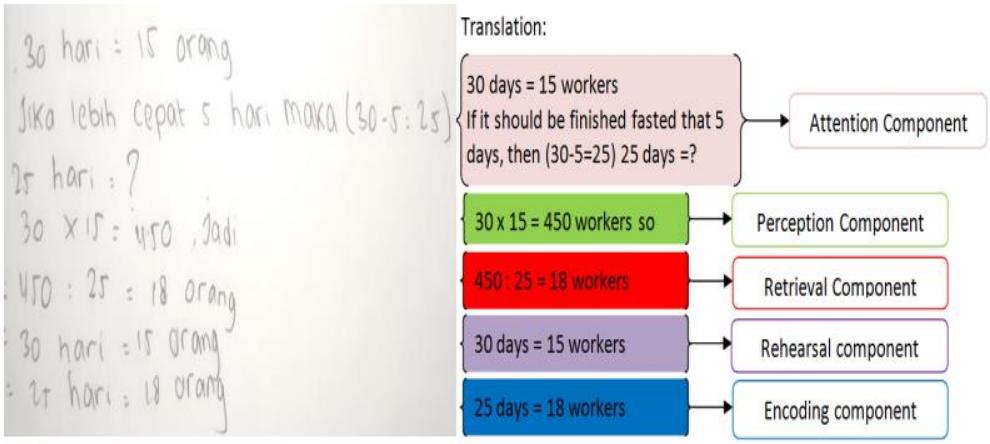

Figure 3: S2 Subject's Thinking Process in the Multiplication Category

The occurrence of the S2 subject's thinking process related to the inverse proportion problem can be seen from the following interview results.

Table 5: Interview Results of S2 Subjects

Researcher	:	From the questions you just read, do you understand?
S2	:	Yes, I do, sir.
Researcher	:	Question about what?
S2	:	The problem is about the inverse of proportion
Researcher	:	From this question, what is known?
S2	:	It is known that 30 days equals 15 people. If, 5 days sooner than 30 days minus 5 days equals 25 days.
Researcher	:	Then, what is asked in the question?
S2	:	If they work 25 days, how many workers are needed?
Researcher	:	Next, how do you plan to solve the problem?
S2	:	30 days multiply by 15 people equals 450.
Researcher	:	30 days multiply by 15 people equals 450.
S2	:	Euuu..... The result of multiplying 30 by 15 (subject S2 is confused)
Researcher	:	Then, the next step?
S2	:	450 divided by 25 equals 18 people.
Researcher	:	Why are you writing back 30 days equals 15 people?
S2	:	Yes, because the previously targeted work was 30 days with 15 workers.
Researcher	:	The results of the work you get from the first step to finding the result, your conclusion What?
S2	:	Work is 5 days faster, so 25 working days requires 18 workers.

Attention is the focus on the offered information, which decides what is known and desired in the problem. After the stages of attention and perception, the S2 subject revealed a problem-solving strategy based on a multiplication process for processing the incoming information. In order to process information, the S2 subject retrieves information from long-term memory to short-term memory while perceiving. 30 days' worth of retrieval results multiplied by 15 people equals 450. Using the processes of multiplication and division, 450 divided by 25 is 18. Subject S2 continued retrieval from short-term memory, but a rehearsal process occurred, as subject S2 repeated previously provided information by writing it. At the encoding stage, it is in the form of a conclusion explaining each step that was carried out and then concluding the results of the completion. S2 subject determined that 18 people were required for 25 working days. The S2 subject's memory effectively stores the knowledge required to process information. Information retained in short-term memory is again stored in long-term memory, or encoded, by S2 subject.

Data Exposure and Analysis of the Occurrence of Thinking Interference

S3 subject was presented under the category of thinking interference. Based on interview data, field notes, and subject answer sheets, this article offers data interference reasoning for addressing inverse proportion problems within the context of the information processing theory. Thinking interference occurs in the "perception" component, which is a difficulty connected to the inverse of proportions, but which may be handled by employing direct proportions.

(S3) Description of Subject Thinking Process

The description of the occurrence of thinking interference in the subject of S3 was analyzed based on the components of

information processing theory. The components of information processing theory involve attention, perception, rehearsal, retrieval, and encoding. The S3 subject observes and reads the questions given, then stores the information into sensory recordings through the senses. Because sensory recordings are the outer storage areas that directly capture information or directly deal with the information provided. The thinking process of the S3 subject can be shown in Figure 4 below.

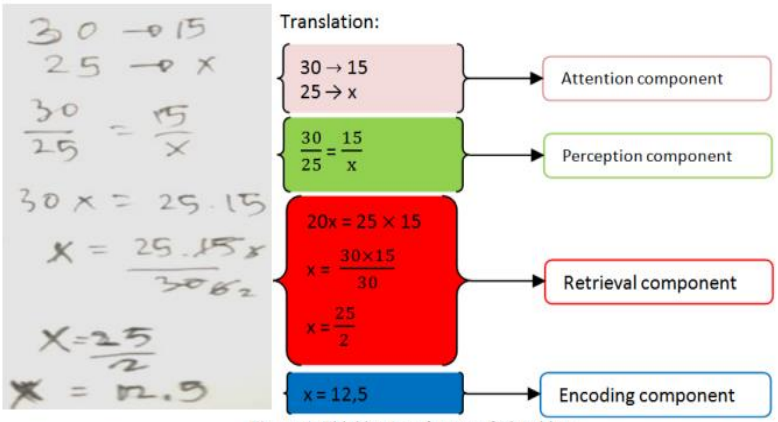

Figure 4: Thinking Interference of S3 Subject

The description of the occurrence of interference in S3 subject's thinking related to the problem of inverse proportions can be seen from the following interview results.

Table 6: Interview Results of S3 Subjects

Reseacher	:	Question about what?
S3	:	About proportion inverse.
Reseacher	:	From this question what is known?
S3	:	It is known that 15 workers can complete a job in 30 days.
Reseacher	:	Then, what is asked in the question?
S3	:	How many workers in 25 days.
Reseacher	:	Next, how do you plan to solve the problem?
S3	:	Next, how do you plan to solve the problem?
Reseacher	:	Try to explain the inverse proportion formula that you know?
S3	:	As far as I know the inverse proportion formula is a/b = c/d
Reseacher	:	As far as I know the inverse proportion formula is a/b = c/d
S3	:	Suppose a is 30 days, b is 25 days, c is 15 people, and we will look for the value of d.
Reseacher	:	Then, the next step?
S3	:	Substitute into the formula
Reseacher	:	Why write down 30x = 25×15?
S3	:	30 times x, 25 times 15
Reseacher	:	The results of the work you get from the first step to finding the result, your conclusion What?
S3	:	What I found was 12.5.
Reseacher	:	Are you sure your answer is correct?
S3	:	Not sure sir! (subject S3 doubts about the answer)

The focus on the information provided and then writing down what is known and asked in the problem is referred to as attention. S3 subjects understood that what was known in the problem was that a total of 15 workers could complete a job in 30 days. Next, write down what is being asked in the question: how many workers are there in 25 days? Perception appears in S3 as a result of paying attention to the received information as an initial plan to determine the formula that can be used to obtain a complete answer. The S3 subject expressed a problem-solving plan by writing a/b = c/d. The perception made by the S3 subject is confused, or there is interference in thinking, namely, problems that should be solved using the inverse proportion formula but are solved using the direct proportion formula. After realizing perception, the S3 subject retrieves information stored in long-term memory and transfers it to short-term memory to process information. The retrieval results obtained are 30 days multiplied by x and 25 days multiplied by 15 people. In the encoding stage, it is a conclusion that explains each step that has been done and concludes the results of the completion. The completion result obtained by S3 subject was 12.5. Thus, the process of completing the S3 subject in solving the inverse proportion problem can be said to be incomplete.

Discussion

Using the theory of information processing, this study aims to examine how students solve problems involving direct and inverse proportions. The s tudents in seventh grade at State Junior High School 1 Kota Ternate who had studied proportions were the subjects of this study. Assuming that seventh graders are taught proportional material as part of the

school curriculum. There were 26 students who participated in this study, but the researcher only gave the results of the number of subjects used as representatives to address the problem of direct and inverse proportions in this discussion. In view of this, the following discussion will examine how students solve direct and inverse proportions using the idea of information processing.

Based on the findings of the research conducted, three categories of students' thinking processes were found, namely (1) the multiple thinking category was carried out by S1 subject, (2) the multiplication thinking category was carried out by S2 subject, and (3) the thinking interference category was carried out by S3 subject. The three categories of thinking can then be analyzed based on the components of information processing theory. The components of information processing theory consist of sensory recording, attention, perception, rehearsal, retrieval, and encoding.

First category, Specifically, multiplication thinking can be studied using the components of the theory of information processing. When direct proportion questions are presented, S1 subject attentively and thoroughly examine the relevant information and then store it in their sensory organs as sensory recording. According to (Slavin, 2006), sensory recording can function to receive a large amount of information through the senses and then store it in a very short time. After this information was obtained from sensory recordings, the S1 subject paid attention to the information received by mentioning what was known and what was asked in the problem. According to (Gurbin, 2015), attention involves selecting some information to process while blocking other information from further processing. S1 subject understands that what is known in the problem is two trips with a total distance of 10 km. Furthermore, S1 subject revealed that what was asked in the question was the number of trips made if the total distance traveled was 30 km.

In S1 subject, perception occurs after the results of attention. The S1 subject's perception of the information received served as the basis for defining the processing strategy. If students identify a problem and then erroneously define it, the students should develop various strategies for reaching the proper conclusions (Weber, 2001). The strategy that S1 subjects can use in solving this direct proportion problem is called perception. S1 subject revealed the perception that in each round, it can be multiplied by 5 up to the number of rounds to get a distance of 30 km. Furthermore, the information obtained by S1 subject from long-term memory is then transferred to short-term memory for further processing. The process of calling the information obtained from these two memories is called retrieval (Gurbin, 2015).

At this stage, subject S1 obtained retrieval results by writing that two trips equaled 10 km, four trips equaled 20 km, and six trips equaled 30 km. Subject S1's long-term memory retains the concept of direct proportion well, so that it can obtain six trips over a distance of 30 km. Subject S1 is able to perform a retrieval to respond to a stimulus in short-term memory, so as to obtain the response needed and draw the right conclusions. Knowledge that has been recalled or information stored in short-term memory is stored again in long-term memory, in other words, subject S1 does the encoding. In the encoding component, the S1 subject explained each step that had been carried out and then concluded from the results of the completion.

Second category, Specifically, multiplication thinking can be studied using the components of the theory of information processing. When presented with the inverse proportion question, S2 subject reads deliberately and extensively before storing the information through sensory recordings. If the data entered into the sensory recorders does not undergo a procedure, the data will swiftly vanish. This memory system happens in only 12 second for visual stimuli and 3 seconds for auditory stimuli, according to (Lutz & Huitt, 2003). However, sensory recording has a significant implication: in order to memorize information, one must pay close attention to it (Slavin, 2006).

After information was obtained from sensory recordings, Subject S2 paid attention to the information received by mentioning what was known and what was asked in the questions. According (Gurbin, 2015), attention involves selecting some information to process while blocking other information from further processing. New information must have some meaning to the student, otherwise it may not persist in the student's memory.

After the attention stage, S2 subject gives perception of the information received as a cloud plan to determine strategies or formulas that can be used to obtain the right problem solving. When realizing perception, S2 subject retrieves information stored in long-term memory and transfers it to short-term memory to process this information. Furthermore, S2 subject continued to retrieval to short-term memory, but a rehearsal process occurred. Subject S2 repeats by writing back the information that was previously disclosed. According to (Slavin, 2006), rehearsal is the repetition of information that has been previously given to a question or the repetition of concepts that have previously been applied in short-term memory.

Encoding takes the form of conclusions that explain each completed phase and summarize the completion's findings. S2 s ubject determined that 18 people were required for 25 working days. S2 subject's memory effectively stores the knowledge required to process information. Information recorded in short-term memory is again stored in long-term memory; subject S2 has encoded the information. For knowledge to endure, it must be encoded and transferred into long-term memory in a complex manner. According (Gurbin, 2015), for long-term storage of information, connections are made through coding with strategies such as inferring, organizing, and elaborating.

Third category, On the base of the information processing component, the interference of thought performed by S3 subject may be examined. When presented with questions pertaining to the inverse of proportions, the S3 subject reads deliberately and completely before storing the information through sensory recordings. If the data entered into the sensory recorders does not undergo a procedure, the data will swiftly vanish. According (Slavin, 2006), sensory recordings have important implications, one must pay attention to information if it is to be remembered. After information is obtained from sensory recordings, S3 subject pays attention to the information received. Attention is the focus by reading the questions carefully and thoroughly on the information obtained so that it can be understood and remembered. This can be supported by opinions of (Santrock, 2008), which stated that Information processed

through attention can concentrate and focus mental resources. The focus is on the information received, followed by the recording of what is known and what is being requested in the problem. S3 subject wrote that, based on what was known about the problem, 15 workers could complete the task in 30 days. In addition, S3 subject wrote that the question asked for the number of workers in 25 days. This information is also supported by the findings of interviews conducted by researchers in the classroom. To help completion of the perception stage, S3 subject recorded what was known and requested in the questions. S3 subject perceives after the outcomes of attention have occurred. S3 subject provides a perspective of the obtained information as a first plan for selecting the solution approach to the provided challenge.

S3 subject achieved perception in short-term memory based on selection, which was subsequently processed further. Information gained from long-term memory in the form of an inverse proportion is then transmitted to short-term memory for further processing. Yet, the problem solving procedure carried out by S3 subject was confused or there was interference in thinking, specifically problems that should be addressed using inverse proportions, but S3 subject solved using direct proportions. S3 subject's thought interference occurs because while discovering a problem-solving approach, S3 subject tends to have difficulties separating the two comparisons. According to (Slavin, 2006), interference happens when two or more pieces of information are jumbled together or when one piece of information is blocked by another. The interference observed by S3 subject likely to occur because to similarities in the two problem structures.

After seeing, S3subject pulls information from long-term memory and transfers it to short-term memory for processing. In addition, S3 subject concluded that the achieved completion score was 12.5. Thus, the completion of S3 subject topic in answering the inverse proportion problem is incomplete. According to (Santrock, 2008), In order to solve a problem, students must be able to generate methods or novel solutions for the problems they confront. If students identify an problem and then mistakenly characterize it, they must build many solutions to the problem in order to reach the correct conclusions. In addition, pupils made errors while addressing problems involving inverse proportions, in part because the notion of proportion was not firmly ingrained in their recollections. As stated by (Sumarto, et al., 2013), inverse proportion is taught formally in class but the way to teach inverse proportion by giving multiplication is meaningless for students, they just memorize the procedure without understanding how it works. Therefore, in solving inverse proportion problems, teachers should explain using multiplication involving proportion situations.

Conclusion

This research aims to reveal students' thinking processes in solving problems of direct proportions and inverse proportions. In light of information processing theory, the question that must be solved in this study is how junior high school students' thinking processes tackle the problem of direct and inverse proportions. Students' thinking processes in solving the problem of direct proportions and inverse proportions by incorporating components of information processing theory can be classified into three categories based on the problem formulation questions: the multiple thinking category, the multiplication thinking category, and the thinking interference category. Subjects in the multiple thinking category in completing direct proportion problems exhibited the attention component, meaning focused on reading the questions thoroughly and attentively based on the information acquired, and then recording what was known and requested in the questions. On the perception component, write or speak a problem-solving plan. In the retrieval component, the act of remembering stored information from memory. Explain each completion step in the encoding section and then draw a conclusion based on the findings of the solution. Subject in the category of multiplication thinking solved problems involving inverse proportions by focusing on reading the questions carefully and completely, then recording what was learned and questioned about the questions. On the perception component, write or speak a problem-solving strategy. In the rehearsal phase, repeating or re-disclosing previously disclosed material. In the retrieval component, the act of remembering stored information from memory. In the encoding section, describe each completed process and then draw a conclusion based on the results. Subjects in the category of thinking interference in completing inverse proportion problems occurred in the attention component, focused on attentively and thoroughly reading the questions and then recording what was understood and questioned about the questions. In the perception part, inverse proportion problems are answered using direct proportions. In the retrieval component, the act of remembering stored information from memory. In the encoding section, describe each completed process and then draw a conclusion based on the results.

Research Limitation And Future Research

The researchers were aware of the limitations of this study, notably that the research subjects were only drawn from one class of 26 students, a very small sample size, and that direct and inverse proportion issues were confined to two items and less diverse. The conclusions of this study are confined to the perception component; thus, it is still feasible to conduct more research to investigate the other components of information processing theory in greater depth. It is suggested that teachers who teach material on direct proportion and inverse proportion teach simultaneously and stress the distinction between direct proportion and inverse proportion.

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