

Using Worked Examples During Geometry Instructions

Nur Irfani^{1,*} Endah Retnowati¹

¹ Faculty Mathematic and Natural Science, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

*Corresponding author. Email: nurirfani.2019@student.uny.ac.id

ABSTRACT

Geometry usually learn in grade seventh and grade eighth on Junior High School. In grade seventh usually study about line and angles. It is a new material for the students, so students can be call as novice learner and it make teacher must more pay attention how to teach the students about line and angles. The aim of this research is to identify the way to manage cognitive load using worked example during geometry instructions based on cognitive load theory. The method of this research is descriptive qualitative research. The data was collected using observation, documentation and interview. The participants of this research is the students of grade seventh in Yogyakarta Junior High School One that there are thirty-four students. The result of this study show worked example can reduce the cognitive load by managing instinsic cognitive load, reducing extraneous cognitive load, and increasing germane cognitive load allocation during geometry instructions. So from this study we can conclude, if using worked example can minimized the cognitive load for novice learner it can be seen during learning geometry and for the next can be analyze for other material that is new for the students.

Keywords: *Worked Example, Cognitive Load Theory, Cognitive Load, Geometry*

1. INTRODUCTION

Learning is a process to acquire knowldege and skills and then store them in memory so that person can understand problems and opportunities in the future [1]. Learning also can be meaning of a positive change in long-term memory, so if in students there is no positive change in their long-term memory then the student has not been said to learn [2]. From these opinions, can be understood if the purpose of learning is a change in long-term memory that can be achieved by the interaction between prior knowledge and new knowledge.

Cognitive system process information during learning process. Therefore, in presenting learning must pay attention to how the cognitive process can build knowledge. One theory that focuses on cognitive processes is cognitive load theory. Cognitive load theory is one of the learning theories that pays great attention to the human cognitive system, this is evidenced by this theory paying attention to instructional involvement in the main characteristics of human cognitive architecture, two important

components that are considered by this theory are working memory and long-term [3].

There is 3 cognitive loads according to cognitive load theory, there are intrinsic cognitive load, extraneous cognitive load, and germane cognitive load [4]. Intrinsic cognitive load related to the complexity of the material has being studied and also related to the prior knowledge of the student have. When students have less prior knowledge, intrinsic cognitive load will be high. Whereas extraneous cognitive load includes the way of the material presented by the teacher to the students. The last is germane cognitive load, this cognitive load comes from the relevant effort in understanding the material in the learning.

Mathematics has a very complex discussion where each material can be related to material that has been studied previously and can also be new material. Mathematics learning emphasizes students' understanding of facts, concepts, principle, and operations in mathematics. Some of these understandings have been formulated in the national curriculum in Indonesia in the form of graduate competency standards (SKL).

Based on the complexity of mathematics, the teacher must have a way to make the learning process is effective. Efforts to achieve effective learning are by managing intrinsic cognitive load, reducing extraneous cognitive load, and increasing germane cognitive load allocation [5]. The implication of cognitive load theory is to produce a learning design that can reduce students' cognitive load. Several learning efforts that can reduce cognitive load are goal-free design it's mean a learning design by eliminating the final goal of a given problem, the other design is worked example design, it's mean by giving examples of problems with solutions, avoiding the split attention and redundancy effect. The split attention can separate the concentration of the student and the redundancy effect raise because of different sources present the same information.

One example of complexity material in mathematic is Geometry. Usually, in grade 7 and 8 in Junior High School will study this material. Geometry is a new material in this grade,so in this position students will becomes novice learners. In this grade usually, student learns about theorems related to angles that formed by two parallel lines and transverse lines. There are 9 theorems, they are (1) The complete rotation angles, (2) The opposite angles, (3) The angles in a quadrilateral, (4) The suplement angles, (5) The angles in a triangle, (6) The corresponding angles, (7) The consecutive interior/exterior angles, (8) The complement angles, and (9) The alternate interior/exterior angles [6].

The problem in geometry not in the form of word problem but the missing angle that presents in the picture, for example in figure 1.

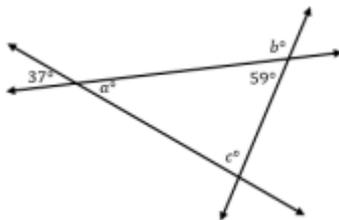


Figure 1 The example of Geometry problem

There are many ways to solve the problem. There are list of strategies to solve the problem, they are (1) Look for a pattern, (2) Make a table (3) use a guess and check, (4) to find a solution of the problem can check from the simpler or special case to gain insight, (5) Write an equation, (6) Make a diagram, (7) Identify subgoal (8) Work backward and (9) Examine related problems and determine if the same technique can be applied [6]. Not all of the strategies were used at once when doing the problem but this depends on the needs of the problem and depends on the student that solving the problem.

Based on figure 1 there a very complex problem to find the missing angles and it's will be very difficult for

students. Students must visualize the angle by two parallel lines and transverse lines. The conventional way usually use by novice learners, but it's not effective to solve the problem because influenced by mean end analysis [7], this strategy usually use when the knowledge in insufficient. The student with insufficient prior knowledge may very difficult to found the new knowledge suggest by cognitive load theory [8]. So the student needs an assistance or scaffolding to construct knowledge that appropriate to the problem-solving and can create an effective learning environment [9].

Cognitive load theory suggests to presentation the material using worked example to reduce the cognitive load for novice learners. There are problems, ways of solving, and explanations that presented step by step in getting solutions. It can make students learn more focused and can reduce the cognitive load. So, the worked example can be reduce the cognitive load in geometry and what is way to reducing the cognitive load during teaching will be discussed further.

2. METHOD

This research is a qualitative descriptive study. The purpose of descriptive research is to analyze problems and present facts systematically. The participants of this research were 34 students of grade 7 in Sleman, Yogyakarta. The research procedures using 4 stages, the first stage is selected the samples by purposive sampling. Purposive sampling is a technique where researchers choose samples that meet the characteristics to be exported in this research [10]. For can choose the samples according to the criteria, the researchers obtained a recommendation from experts, in this case, is a teacher of mathematics at the school because the teacher already understand about the characteristics of the students. The second stage is collecting data through observation, documentation, and interviews. Interviews conducted to validate the data [11]. The third stage is the data analysis phase. The analysis data with documentation is by a written test. It will be a range of the point. The written test is a 10 questions about geometry. It has the same value of the number of question. The minimum point is 0 and the maximum point is 100. The last stage is validity of the data by extended observations, data triangulation, and systematic analysis of research results.

3. RESULTS AND DISCUSSION

3.1. The Steps of Using Worked Example During Geometry Instructions

A Worked example is presented in worksheets that have problems and solutions with the correct one. Presenting the problem in work example can make the attention of students is fully attention learn how the problem should be solved, more than solving the problem [12]. There are 4 steps to using worked example in the learning process, they are (1) Apperception, (2) Student read the worksheet of worked example and solve the geometry problem with the strategies that already show in the example, (3) Students present the result of their work, (4) Teacher guide the students to conclude the learning.

(1) Apperception

This activity mainly aims to recall the relevant knowledge in student’s memory. The apperception presenting by make an examples and problems on a one page in worked example worksheet. In this step not only remind students to the theorems, but began to be introduced the material of geometry to the forms that have been modified in more complex problems. Integrating the old information with the new information may assist to make new information [13]. In the end teacher ask students about the theorems that have been studied and what theorems are needed to solve the geometry problem.

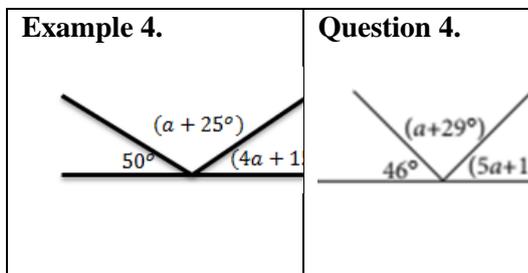


Figure 2 The example of Worksheet for Apperception

(2) Student Read the Worksheet Of Worked Example and Solve the Geometry Problem With the Strategies that Already Show in the Example

After students read the example and understanding it, students read and understand the question of geometry problems and try to solve it using strategies that presented in the worksheet of worked example. The design of worked example must be can guide students to understand how to finished the problems[12]. The instruction in the worksheet should be clearly, so students can maximize the knowledge when using the worksheet. If when learn using worked example better students read the commands together and then the

teacher explain until the students understand well about what the wants of the questions but not in every question just a little of question. Sometimes needs explanation in the worked example, because it can give a positive effect on the acquisition of the conceptual knowledge [7]. The teacher can tell the students if they can use the auxiliary line or remember what the angle that formed of the sum line in the question. The solution that use in the worked example is the solution of an expert way when solve the problems, so students can understand it and learn . Students must accompany the way to get solution in the worksheet, then understand the step by step. Students also can add other information with their language to make the solution better.

If students already understanding the example well, students should do the other problem without looking the example. It can be done, with make the example and the problem presented in a different page so students do not hang on the example. On the other side, the teacher also must motivate students to understand the example well and then do the problem by themselves using their understanding. The teacher also can remind the students who always see the example repeatedly. The teacher should explain that important to understanding the way of the solution that memorizing them.

The teacher give time to understanding and doing the paired example and problem to the students. Usually, students with sufficient knowledge can understand faster than insufficient students. In practice, students take almost 10 minutes to understand the example and solve the problem. Using an auxiliary line assist students to find the missing angles.

(3) Students Present the Result of Their Work in Front of the Class

Students who already finish the worksheet thoroughly, can present their results in front of the class. It can help students that can finish the problem but can not explain it because they can’t understand the meaning. In this activities, teacher and students can discuss the way of the result, and can confirm the student’s answer. In the end, teacher can give the important point that they must remember when solving the problem without a pairing example.

(4) Teacher guides the students to conclude the learning

At the end of the learning process, the teacher guide students to conclude about what they can gain in the learning process. It was important to give students about the keywords that needs to understand by students. With these steps, students can keep the knowledge in long-term memory and can be recalled if they need this knowledge.

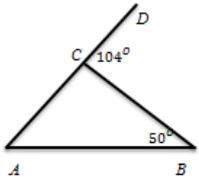
3.2. Worked Example for Reducing in Geometry Problem

The extraneous cognitive load can reduce by worked example [2], and learning can be increase through the construction of new schematic knowledge [7],[12]. There are many studies that discuss solving geometry problems using worked example by researchers [6],[2],[13],[14],[15],[16],[17].

The extraneous cognitive load can be reduce by worked example through avoiding a split-attention effect, redundancy effect, and expertise reversal effect [5]. The three-way that one will be described as follows:

- (1) Split attention effect can caused by the presentation of information sources separately. For example, instances, where students have to repeat and read the question, match it with a new image or other information to work on it, can make students cannot focus on just one statement but still have to match to allow for a student's attention solver, such as Figure 3 and Figure 4.

see the picture below!
find $\angle BAC$.



Penyelesaian :
 $\angle ACB + \angle DCB = 180^\circ$
 $\angle ACB + 104^\circ = 180^\circ$
 $\angle ACB = 180^\circ - 104^\circ$
 $\angle ACB = 76^\circ$
 $\angle BAC$ was on the triangle ABC , so to find it is,
 $\angle BAC = 180^\circ - 50^\circ - 76^\circ$
 $\angle BAC = 54^\circ$

Figure 3 Example geometry problem with split attention effect

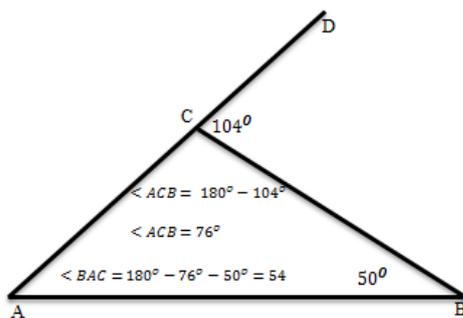


Figure 4 Example geometry problem without split attention effect

Based on the picture and explanation above, the management of split attention effect can be done by manging information and presenting information in an integrated manner. The material presented without the split attention effect will facilitate students because it has minimized extraneous cognitive load.

- (2) Redundancy effect occurs when the information given to students is excessive and does not need to be used. Redundancy effect can be the main reason for instructional mistakes made by students. The teacher must minimize the information of the clue in the question, the over information can make the students confuse. In learning geometry, it can be presented in the figure below.

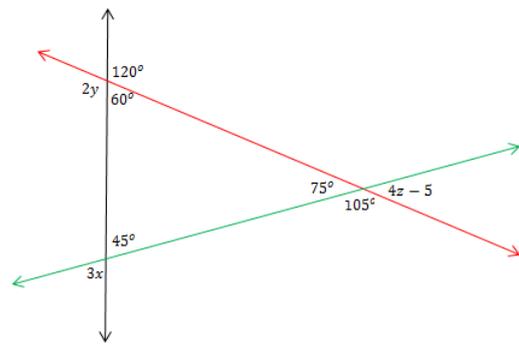


Figure 5 Example geometry problem with redundancy effect

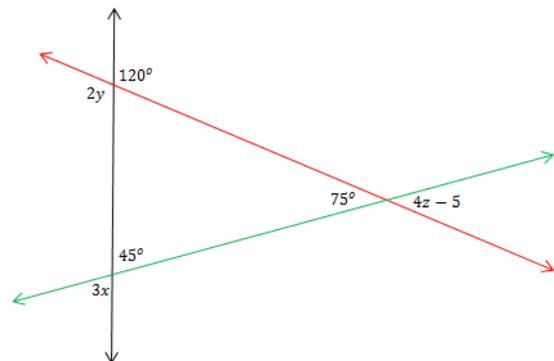


Figure 6 Example geometry problem without redundancy effect

Based on the picture and explanation about the redundancy effect, giving more information can separate the student's attention about the main focus. The main focus of the question in the figure above is to find the x, y, and z using the opposite angles but giving the additional information makes the students think "what we must do with the number this one (60°). Almost all of the students still think, if in the math all of the

number in the question has functioned so must be used. In practice, this opinion true when the teacher gives the students figure 4 some students ask how about 60° , the students ask if use $60^\circ + 2y = 180^\circ$. It will make students not get the aims of learning.

- (3) Expertise reversal effect can occur due to an imbalance between the presentation of material and student's initial knowledge. The use of worked examples will be considered long and excessive by students who have sufficient initial knowledge, but instead it becomes a helper for students who are still lacking to be able to earn independently with worked examples. So, before the study and using a worked example teacher must give the students apperception to make the prior knowledge almost the same between one student to another.

Based on this explanation, worked example in cognitive load theory effectively reduces cognitive load in learning because they can manage intrinsic cognitive load and extraneous cognitive load. Managing intrinsic cognitive load means managing the complexity of the material while managing extraneous cognitive load can be done by avoiding split attention, redundancy effects, and expertise reversal effects. Using worked example also can minimize germane cognitive load, because students not need found another worksheet if want to solve the problem and want to learn more.

4. CONCLUSION

Geometry is a new material, so students will become a novice learner in this conditions. Because it is a new material so it will become difficult and can make the cognitive load. So the students need an learning approach that can help them to manage cognitive load. Based on the cognitive load theory, worked example one of the approach that can be manage the cognitive load. Cognitive load can be manage or reduce by managing intrinsic cognitive load, reducing extraneous cognitive load and increasing germane cognitive load allocation during geometry instruction. Managing intrinsic cognitive load is done by presented the paired of example and question in the one page. The example and the question that present in the one page have the same context of question, so students can follow the steps to find solution in the example to solve the question. The extraneous cognitive load is done by pay attention of the picture during geometry instructions. Teacher must true when draw the picture, if teacher false when present the picture it can make a redundancy effect. The germane cognitive load is done by because using worked example students don't need to find other souch to help them understand the geometry because worksheet worked example already complete to learn. For the next study that want to identify worked example during geometry instructions can be make the

design of worked example by following the research that already have with the modified.

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