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Increasing students' creative thinking skills at 11th grade of mathematics and natural sciences 5, Senior High School 42 Jakarta on subject of Temperature and Heat by applying discovery learning model

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Abstract. The purpose of this research is to increase the student's creative thinking skills by applying Discovery Learning on subject of Temperature and Heat subject. This research was done by July 2018 to November 2018. The method used on this research is Class Action Research (CAR) method which was done within two cycles with Planning, Acting, Observing, and Reflecting stages. The aspects that measured on this research are the creative thinking skill which covering the aspect of Fluency, Flexibility, Elaboration, and Originality. Syntax of discovery learning model that applied in this research is stimulation, problem statement, data collection, data processing, verification, and generalization. The total score of creative thinking skill in cycle 1 was 54,35%, in cycle 2 was 60,65%. So, the average score of the skill to think creatively was 57,5%, refer to table 1, the student's way in thinking creatively were "enough creative". The pretest was been held obtained that average results of students score was 55 and the posttest results was 73. On post test results 73 known that student has been reached minimal completeness of physics subject as big as 70 refer to the rules from Senior High School 42 Jakarta. It can be concluded that students' creative thinking skills has increased by applying Discovery Learning model on temperature and heat subject..

1. Introduction

1.1. Background Issues

The learning targeted was the innovative learning, relevant with needs and active role of students on study. This matches with Jufri said that organizer system of learning and scoring of students' result of study needs changed from teacher-centered learning to student-centered learning [6]. The fact of science or physics is a science about natural phenomenon that served with form of fact, concept, principle, and law that verified its correctness by going through series of activities in scientific method [11]. There were still a lot of educators that using method and conventional medium on teaching learning subjects, especially on physics. Subjects that presented became boring because teacher use conventional medium such as printed module and with preaching-style learning model. The weakness is if students not applied with interesting module from the subjects that presented, students will having a hard time returning back to the learning subject process.

The success of an educational goal depends on how the process of learning that students experienced. Teacher forced to elaborate and apply learning method that suits with goals they want to achieved and



capable to choose medium that suits with subjects [9]. Physics is one of the basics of natural science that studies natural phenomenon and also its entire interaction that could cause why that phenomenon could happen.

Giancoli stated that physics is a fundamental science because it correlates with behavior and structure of things. In Indonesia, physics could begin since experiencing middle school [3]. But, it cannot change fact that physics is one of the subjects that assumed hard and bored by students. This happen because physics contains a lot of abstract concept and principle. In physics, someone must has the ability to think act rationally. Thinking is one process to acquire knowledge. Furthermore, human thinking skills based on its process could categorized into two types, basics and advance thinking skills [7]. Process of advance thinking skills includes critical and creative thinking skills. But in reality process of advance thinking skills which is creative thinking skills is rarely trained at schools.

Creative individual has high confidence, independent, responsibility, and committed to assign, seldom run out of ideas on solving problems, rich of initiatives and more oriented to presents that future and facing past change [12]. The ability of creative thinking skills really needed in order to anticipate and facing changes. Discovery learning model forces student to find new stuffs where in process finds new things. It needs creativity of student so that Discovery learning model with syntax could increase the ability of students creative thinking skills. Brunner define Discovery learning is one of situation where subject that presented is not in its final form, but it needs students mental activity first so that shapes new knowledge in students cognitive structure.

By that explanation, it could be known that Discovery learning model could increase students' ability to think more creatively. But in order to know how big the increase of students creative thinking skills on subject of temperature and heats, then it was done a Class Act Research (CAR) titled Increasing of Creative Thinking Skills of 11th Grade Students of Mathematics and Natural Sciences 5 of Senior High School 42 Jakarta on Subject of Temperature and Heat by Applying Discovery Learning Model.

1.2. Problems Observation

Discovery Learning could increase the creative thinking skills of 11th grade students of mathematics and natural sciences of Senior High School 42 Jakarta?

1.3. Purpose of Research

Purpose of this research is to know the increasing of creative thinking skills of 11th grade students of mathematics and natural sciences of 42 public high school by applying Discovery learning model on temperature and heat subject.

2. Literature Review

2.1. Creative thinking skill

According to Elaine, creative thinking is one of the habits from mind that train by paying attention to intuition, living imagination, revealing new contingencies, opening an amazing point of view, and raising unwanted ideas. While Martin says that creative thinking is the ability to produce new ideas or ways on resulting a product. In general, creative thinking triggered by challenging problem. Thus creativity is a process on thinking that capable to generate different ideas and is a new thing [13].

Aspect of creative thinking is: (1) fluency; ability to create new ideas, answers, problems solving, giving new ways or suggestions to do a lot of stuffs and also think more than just one answer. (2) flexibility; ability to quick-create ideas, answers, or variety of questions on seeing a problems from different point of view. (3) elaboration; ability to enrich and develop an idea or product by detail so that it become more interesting. (4) originality; ability to generate new idea that never done before [10].

A person with creative potential could be known easily through observing characteristic, which is passion to know, open to new experiences, strong mind, desire to find and research, often likes to do hard and heavy tasks, finding answer that comprehensive, passionate, active, and dedicated to do their tasks. Beside that, a creative person is can respond questions, give many answers, make analysis and synthesis, make abstraction, has an inquiry spirits, and have wide background of reading ability. There

is a need for retail merchandising program to emphasize creative problem solving because creativity can be learned [5].

2.2. *Discovery Learning Model*

Discovery is a process of learning that focused on mental intellectuality on student when solving kind of problems that they faced it alone, teachers just guiding and giving a guidance so students could find a concept or generalize which they could applied on field [8]. Discovery is a method that focused on a real experience, where the invention students could get does not necessarily new, because it was already known before. The point that it is not a true invention, but more like an innovation [2]. From the description above it means that Discovery learning is a process that focuses on students' experiences directly in finding solutions to a problem. Discovery learning procedures that must be implemented in teaching and learning activities are as follow [1]:

a. Stimulation (Stimulation or giving stimulation)

Students listen and read what the teacher have to say, or the teacher asks by asking a topic for the problem. At this stage it serves to provide conditions for interaction or discussion of learning that could develop and help students explore materials.

b. Problem statement (question or problem identification)

The teacher gives the opportunity for students to identify the problems that exist and relevant with the learning material.

c. Data collection (data collection)

The teacher provides the chance for students to gather various existing and relevant information in proving whether or not a hypothesis is true. This stage is to answer questions or prove the correctness of the hypothesis.

d. Data processing (data processing)

Activities to process data and information that have been obtained by students through interviewers, observations and so on, are then interpreted. At this stage students will get new knowledge about alternative answers / solutions that need to be verified logically.

e. Verification (evidence)

Teacher gives the opportunity for students to find a concept, theory, rule or understanding through the examples that found in life.

f. Generalization (draw a conclusion / Generalization)

Students can form a conclusion with words / writing about the principles underlying the generalization.

2.2.1. *Advantages of the Discovery Learning*

The model Discovery Learning has several advantages. Following are the advantages of teaching and learning with Discovery learning model:

- a. Submission of Discovery strategy materials is used by direct experience throughout activities. These experiences will attract the attention of students and letting the arrangement of abstract concepts that have more meaning.
- b. Discovery learning is more sensible and meaningful.
- c. Discovery learning is a problem solving model. It enables students to answer more complex life problems.
- d. It is more easily understood by students in certain conditions relating to learning activities.
- e. Provide chance for students to experience directly in learning activities.

2.2.2. *Weakness of Discovery Learning Model*

There are some weaknesses of discovery learning model as follow:

- a. It requires a longer time compared to the direct method.
- b. Their rational thinking ability is still limited. In discovery learning they often use highly empirical subjective methods to strengthen the implementation of the preconceptions.

- c. The difficulty in using this subjectivity factor creates difficulties in understanding a problem relating to discovery learning teaching.
- d. Demanding independence, trust in himself, and the habit of acting as a subject. These demands will at least provide compulsion that cannot be done by using an ordinary activity in the learning process.

2.3. Temperature and Heat

Temperature is a large or small size of energy contained in an object. Temperature can be measured using a device called thermometer. The properties measured to express temperature are called thermometric properties. The unit of temperature is degrees [3].

a. Long Expansion

If the temperature of an object will experience expansion. For example, an object that has a length of ΔL at temperature T will experience a long expansion of ΔL if the temperature is increased by ΔT . Mathematically, the formulation of long expansion can be written as follows.

$$\Delta L = \alpha L_0 \Delta T \quad (1)$$

With α is the long expansion coefficient.

$$\alpha = \frac{\Delta L}{L_0 \Delta T} \quad (2)$$

The unit of the opposite of the temperature unit of the Celsius scale ($1/^\circ\text{C}$) or kelvin ($1/\text{K}$).

b. Expansion of Area

A solid object, both square and cylindrical, must have area and volume. As is the case for long expansion, when objects are heated, in addition to long expansion there will also be extensive expansion. The formulation on the expansion is almost the same as in the long expansion, namely as follows.

$$\Delta A = \beta A_0 \Delta T \quad (3)$$

with β is the board expansion coefficient.

$$\beta = \frac{\Delta A}{A_0 \Delta T} \quad (4)$$

Units of β are $1/\text{K}$ same as long expansion coefficients (α). Let's look at a copper square. For example, the side length of copper is L_0 , then the area of copper is L_0^2 . If the copper is heated to a temperature change of ΔT the copper sides expand and the copper side length becomes $L + \Delta L$. The area of copper after expansion will change to $(L_0 + \Delta L)^2$ and extensive changes after expansion are from the formulation of broad expansion coefficients, namely

$$\begin{aligned} \Delta A &= (L_0 + \Delta L)^2 - L_0^2 \\ \Delta A &= L_0^2 + 2L_0\Delta L + \Delta L^2 - L_0^2 \\ \Delta A &= 2L_0\Delta L + \Delta L^2 \end{aligned}$$

From the formulation of a broad expansion coefficient, namely

$$\beta = \frac{\Delta A}{A_0 \Delta T} = \frac{2L_0\Delta L + \Delta L^2}{L_0^2 \Delta T} \quad (5)$$

Because the changes in the length of the copper ΔL is very small, the ΔL^2 value can be ignored. If rewritten, the equation becomes

$$\beta = \frac{2L_0\Delta L}{L_0^2 \Delta T} = \frac{2\Delta L}{L_0 \Delta T} \quad (6)$$

So,

$$\alpha = \frac{\Delta L}{L_0 \Delta T} \quad (7)$$

$$\beta = 2\alpha \quad (8)$$

c. Volume Expansions

As we discussed before, every solid objects definitely has volume. If length of an object can be expands when heated, then volume of the object also expands. Formulation for volume expansions same with length and wide formulation, that is:

$$\Delta V = \gamma V_0 \Delta T \quad (9)$$

With γ is the volume expands coefficient

$$\gamma = \frac{\Delta V}{V_0 \Delta T} \quad (10)$$

We need to know there is any relations between α and β against γ time, that is:

$$\gamma = 3\alpha = \frac{3}{2}\beta \quad (11)$$

d. Liquid substance expansions

As well as solid substance, liquid substance will expands the volume if heated. Example, when we heating pan that contains full of water, what will happen to that water inside the pan? At really high temperature, some of that water will spill.

This means water volume inside the pan expands or the volume is increase. Most of the substance will expand regularly against increasing temperature. However, water doesn't following ordinary pattern.

e. Gas substance expansions

Gas expansion is not big, because gas in general expands to fill the space. The equation only apply if constant pressure. Gas volume really depends on pressure and temperature. Then, it will really useful for determine the relations between volume, pressure, temperature, and gas mass. Relation like this is called equality of circumstances. If system circumstances is change, we will always waiting until temperature and pressure reach same value overall.

- Boyle Law

by Robert Boyle (1627 – 1691), the first that declare based of the experiment by himself. Pressure chart (P) against gas volume (V) for constant temperature.

$$P V = \text{constant} \quad (12)$$

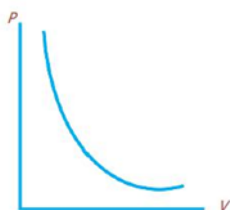


Figure 1. The relationship of P and V at constant temperature

- Charles Law

French scientist, Jacques Charles (1746 – 1823) found that when the gas pressure is not too high and kept constant, the volume of gas increases with temperature at almost constant speed.

$$V/T = \text{Constant} \quad (13)$$

- Gay Lussac's Law

Gay Lussac's law comes from Joseph Gay Lussac (1778 – 1850), stating that at a constant volume, the gas pressure is directly proportional to the absolute temperature, written: $P \propto T$

- Ideal Gas Equation

Gas laws from Boyle, Charles, and Gay Lussac were obtained with the help of a very useful technique in science, namely keeping one or more variables constant to see the effects of changing only one variable. These laws can be combined into a more general relationship between the pressure, volume, and temperature of a certain amount of gas: $PV \propto T$.

$$P/T = \text{Constant} \quad (14)$$

f. Heat

Heat is the transfer of energy that occurs from higher temperature objects to lower temperature objects. Heat can result in changes in the temperature or form of a substance. Acceptance of heat will increase the temperature and can convert solids to liquid or liquid to gas, while the release of heat will reduce the temperature and can convert liquid substances into solid or gaseous substances into liquid. Heat is one form of energy, so it can move from one system to another because of differences in temperature. Conversely, whenever there is a temperature difference between the two systems, there will be heat transfer. For example, the ice put in a glass of hot water, the ice will melt and the water will cool. Because there is a temperature difference between ice and water, the hot water releases some of the heat so that the temperature drops and the ice receives heat so that the temperature rises (melts). The heat given to the substance can change the form of the substance.

g..Heat as energy transfer

Heat flows by itself from an object whose temperature is higher to another object with a lower temperature. In the 18th century illustrated the flow of heat as a movement of fluid substances called calories. When you cook water, you need heat to raise the temperature of the water to boil water. How much heat does water need to raise the temperature to reach the desired temperature? Inductively, the greater the temperature increase of an object, the greater the heat absorbed. In addition, the heat absorbed by objects also depends on the mass of objects and constituent materials. Mathematically can be written as follows.

$$Q = m \times c \times \Delta T \quad (15)$$

Information:

Q: heat absorbed / removed object (J)

m: Mass (kg)

c: Heat type (J/kg°C)

ΔT : change of temperature (°C)

3. Research Method

The research method used is Classroom Action Research. Classroom action research is research that conducted in the classroom with the aim to fix or improve the quality of learning practices. Research procedures are carried out using two cycles. The cycle used refers to the Hopkins cycle, which is planning, acting, observing, and reflecting. The data obtained then calculated and assessed by giving a score. After all the questions are given a score, the next is calculate the percentage score of the answer data for each item with the formula:

$$\text{Answer} = \frac{\text{answer's score}}{\text{ideal score}} \times 100\% \quad (16)$$

Then calculate the percentage score of the answer on each indicator about the test of creative thinking. Each ideal score in percentage is given a weight of 100 and a minimum score of answers weighs 0. Based on the percentage difference of the maximum score and the minimum number of groups of 5, scoring category can be explained at table 1.

Table 1. Criteria for Assessing Thinking Creatively [4]

Answer Percentage (%)	Scoring Category
81 – 100	Very Creative
61 – 80	Creative
41 – 60	Enough Creative
21 – 40	Less Creative
0 – 20	Not Creative

The rule from Senior High School 42 Jakarta, the minimum criteria completeness score of temperature and heat subject is 70.

3.1. Cycle I

3.1.1. Planning Phase. At the planning phase, the researcher is preparing instruments for data collection consisting of test and non-test instruments (non-test instruments in the form of observation sheets to observe student activities and test instruments in the form of questions to measure student's creative thinking abilities (pre-test), and making lesson plans.

3.1.2. Implementation phase. This phase is the implementation of the planning that has been made. First stage is the teacher gives a pretest to find out the student's creative thinking skills. Furthermore, the implementation of class actions is carried out by referring to the RPP that has been made by applying the Discovery learning model. The stages implemented are as follows:

1. Giving stimuli to students in the form of observing images of everyday life phenomena related to the material discussed, namely Heat Temperature.
2. Identification of problems by providing opportunities for students to identify problems from the teacher given by the teacher.
3. Data collection by giving students the opportunity to collect various relevant information related to the existing problems.
4. Students process the data obtained so that students can get new knowledge related to problems that need to be proven logically.
5. Verify data by giving students the opportunity to find a concept, theory, rule or understanding through the examples found in life.
6. Draw conclusions by the way students form conclusions on discussions that have been carried out.



Figure 2. Presenting study video
Stimuli at the beginning of the lesson was given by watching video to motivate students.



Figure 3. Students doing group tasks.
Students were given instruction and problem to solve.



Figure 4. Students doing group
In a group, students discussed how to solve the problem



Figure 5. Presenting study video.
The outcome of group discussion was presented by each group.

3.2. Cycle 2

3.2.1 The planning stage. The planning stage of the cycle 2 refers to the results of reflection on cycle 1 where researchers will be able to pick up the topic related to the application of the temperature and heat was more diverse in everyday life. Besides that teachers are also more motivating students to become active in learning activities and continued by giving posttest to all students.



Figure 6. Briefing by lecturers and teachers related to the result of reflection cycle.
Teachers or researchers gathered to reflect on the application in the classroom to improve the next cycle



Figure 7. Direction by lecturers and tutor teachers related to the results of cycle 1 reflection.
Lecturers and teachers formulated the revised strategies that improved students learning.

3.2.2 The implementation phase. The implementation phase is not much different from what was done in cycle 1. The difference lies in the problems related to the material being studied to be more diverse. The implemented phase are as follows: (1). Provision of stimuli to students in the form of observing several images related to the material discussed, namely temperature and heat. (2). Identification of problems by providing opportunities for students to identify problems from images given by the teacher. (3). Data collection by giving students the opportunity to collect various relevant information related to the existing problems. (4). Students process the data obtained so that students can get new knowledge related to problems that need to be proven logically. (5). Verify data by giving students the opportunity to find a concept, theory, rule or understanding through the examples found in life. (6). Draw conclusions by the way students form conclusions on discussions that have been carried out. Furthermore, at the end of the learning activities, the teacher gave the posttest questions to all existing students in the class to find out the increase in students' creative thinking skills in the material temperature and heat.



Figure 8. Students pay attention to the learning material

3.2.3 The observation phase. From the results of the implementation in cycle 2, it was found that the activity of students in the class became more increasing. This could be seen from the results of discussions held in classrooms where more students are able to express their ideas and ideas with a more diverse perspective.

3.2.4 The reflection phase. Indicator of success has been reached so the implementation is been stopped until second cycle.

Table 2. Research Result Cycle 2

Assessment aspects	cycle 2
<i>Fluency</i> (ability to think smoothly)	65.75%
<i>Flexibility</i> (ability to think flexible)	67.43%
<i>Elaboration</i> (ability to detailed)	58.26%
<i>Originality</i> (ability to think original)	51.18%

4. Results and Discussion

The steps of research results classroom action research that has been held by the researchers on XI mathematics and natural sciences class in nation senior high school 42 Jakarta by applying 2nd cycle consist of planning, acting, observing, and reflecting. When the pretest was been held obtained that average results of students score was 55 and the posttest results was 73. On post test results 73 known that student has been reached minimal completeness of physics subject as big as 70 refer to the rules from Senior High School 42 Jakarta. On two cycle of implementation looks that student enthusiastic in learning activity that has been delivered by the teacher, beside that the students look active when deliver their idea. Discovery learning model aimed to increase students creative thinking skill. Measured aspects in this research is creative thinking skill which cover aspects fluency (ability to think smoothly),

Flexibility (ability to think flexible), Elaboration (ability to detailed), and Originality (ability to think original). As for the results of students' creative thinking abilities is obtained by the researchers is.

Table 3. Comparison Student's Creative Thinking Skills in Cycle 1 and cycle 2

Assessment aspects	Cycle 1	Cycle 2
Fluency (ability to think smoothly)	51,27%	65,75%
Flexibility (ability to think flexible)	60,31%	67,43%
Elaboration (ability to detailed)	55,70%	58,26%
Originality (ability to think original)	50,14%	51,18%
Average Total Score of Creative thinking Skill	54,35%	60,65%

The average total score of creative thinking skill in cycle 1 was 54,35%, in cycle 2 was 60,65%. So, the score of thinking creatively was 57,5%. Refer to table 1, the student's skill of creative thinking were "enough creative" with the improvement was 6,33%.

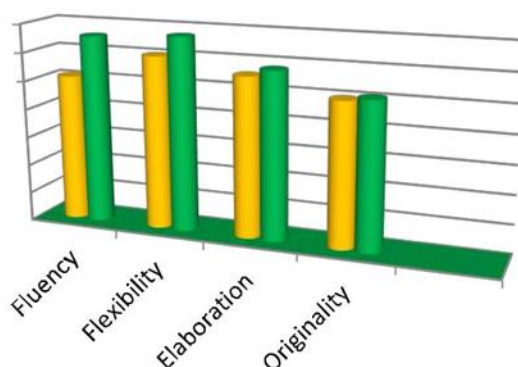


Figure 9. Graphic the Increasing of Student's Creative Thinking Skills

In cycle 1 obtained results on creative thinking skill which cover aspects fluency (ability to think smoothly) as big as 51.27% which include in enough creative criteria, Flexibility (ability to think flexible) as big as 60.31% which include in enough creative criteria, Elaboration (ability to detailed) as big as 55.70% which include in enough creative criteria and (ability to think original) as big as 50.14% which include in enough creative criteria. Overall obtained that student creative thinking skill is in in enough creative criteria so it's need to be implemented cycle 2 for reach the target wanted.

In cycle 2 there is a raise in students' skill of thinking creatively in all aspects assessed. This can be inferred from the activeness of students in the classroom during learning activities where students are more daring to express their ideas and ideas. Besides that the ideas conveyed by each student also vary based on the students' own thinking. On the fluency aspect (ability to think fluently) students experience an increase of 14.48% included in the criteria of both creative, aspect flexibility (flexible thinking ability) students experience an increase of 7.12% included in creative criteria, aspects of elaboration (ability to think) students experienced an increase of 2.56% included in the creative criteria, and aspects of originality (original thinking ability) of students experienced an increase of 1.04% included in the criteria quite creative. Then the average increase in 'creative thinking skills of students by applying discovery learning models of 6.33% from cycle 1 to cycle 2. This research has acquired the average increase of student's creative thinking skills by applying Discovery Learning model, the total score of creative thinking skill in cycle 1 was 54,35%, in cycle 2 was 60,65%, with the increasing score by 6,33%. So, the average score shown was 57,5% for creative thinking, refer to table 1, the student's creative thinking skill were "enough creative". The pretest was been held obtained that average results of students score was 55 and the posttest results was 73. On post test results 73 known that student has

been reached minimal completeness of physics subject as big as 70 refer to the rules from Senior High School 42 Jakarta.

5. Conclusion

From this classroom action research (CAR) that has been implemented, it can be concluded that students' creative thinking skills has increased by applying Discovery Learning model on temperature and heat subject.

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