The effect of learning models and divergent thinking on higher-order thinking skills

R Hidayati, Y Supriyati and A S Budi
Department of Physics Education, Universitas Negeri Jakarta
Jl. Rawamangun Muka, Jakarta 13220, Indonesia
Email: riahidayati2727@gmail.com, yetti.supriyati@unj.ac.id, agussb@unj.ac.id

Abstract. This study aims to determine the effect of interaction between Problem Based Learning models, Creative Problem-Solving models, and divergent thinking on high order thinking skills. The method used in this study is a quasi-experimental design with treatment by level 2x2. The sample number of this study is as many as 120 students of grade X high school. The sample was divided into two, namely the control class and the experimental class. The control class was given learning using the Problem Based Learning model while the experimental class used the Creative Problem Solving model by having high and low divergent thinking skills. Data about students’ high order thinking skills were obtained using a test in the form of an essay consisting of 5 questions and analyzed using the two-way ANOVA statistical test and the Tukey test as a follow-up test. The results showed that 1) there is a difference in high order thinking students who use the creative problem-solving model with students who use the problem-based learning model, 2) there is a difference in high order thinking skills between students with high divergent thinking ability with low divergent ability students and 3) there is an influence of interaction between learning model and divergent thinking ability to high order thinking skill.

1. Introduction
Physics is one of the subjects that is considered important to be taught as a vehicle to develop higher proficiency to develop science and technology [1]. Entering the 21st century, science and technology are developing very rapidly. The rapid pace of development of science and technology certainly impacts challenges and competition by every country globally [2]. To be able to play a role in the global world, every country is absolutely to prepare a generation that has 21st Century Skills. The best way that can be done to make it happen is through education. According to the National Education Association (2002) states that 18 kinds of 21st Century Skills need to be supplied to each individual, one of which is Learning and Innovation Skills which consists of 4 aspects, namely critical thinking, communication, collaboration, and creativity [3]. Critical thinking is one of the skills of high-order thinking skills which is a skill that students must have in solving a problem. One's thinking ability can affect learning ability, speed, and effectiveness of learning [4]. The ability to think is needed in solving problems, especially in physics [5]. Higher-order thinking skills are an important aspect of teaching and learning. High-order thinking skills include the ability to analyze, evaluate, and create [4]. While divergent thinking is the ability of individuals to find various alternative answers to a
problem [6]. The ability of students in solving high-level questions is still low, especially on questions C4 and C5 [7]. The lack of students’ ability to solve high-level questions is due to the lack of developing high-level students’ thinking skills in the learning process [8]. Learning models that are seen as being able to help and facilitate to facilitate students in mastering physics concepts and practice developing higher-order thinking skills, one of which is the Creative Problem Solving (CPS) learning model because with the Creative Problem Solving learning model students will be more active in the learning process and students will be accustomed to solving and developing their mindset in dealing with a problem [9]. In addition to the reasons above, several studies have proven that problem-solving learning models can also improve higher-order thinking skills according to research results which state that problem-based learning models are effective for improving students’ higher-order thinking skills [10].

2. Method
This research is research in the form of a quasi-experimental design (quasi-experimental) with treatment by level 2 x 2. In this study, there are two independent variables, namely the learning model (treatment variable) and divergent thinking ability (attribute variable), and one dependent variable, namely High Order Thinking Skills. The independent variables are grouped into two types, namely Problem Based Learning models and Creative Problem-Solving models, while divergent thinking skills consist of high divergent thinking skills and low divergent thinking abilities.

| Divergent Thinking | Learning Models          |
|--------------------|--------------------------|
|                    | Creative Problem Solving | Problem Based Learning |
| High               | A1B1                     | A2B1                     |
| Low                | A1B2                     | A2B2                     |

This design has a control group, but cannot function fully to control external variables that affect the implementation of the experiment [11]. This study used two classes, namely, the control class was treated using the Problem Based Learning model while the experimental class was treated using the Creative Problem Solving model. The focus of this research is to analyze the differences in High Order Thinking Skills on the material of Elasticity and Hooke’s Law of class X students based on the differences in the level of students’ divergent thinking abilities.

3. Results and Discussion
The summary of data regarding students’ high-order thinking skills can be seen in Table 2 below. Based on the results of the high-order thinking skill test of students who took part in learning the creative problem-solving model, the students’ maximum score = 100, minimum score = 35, and average = 74.58. Meanwhile, for the results of the high order thinking skill test of students who took part in the problem-based learning model, the maximum score of students = 100, the minimum score of students = 30, and the average = 72.50. Furthermore, for the test results of high order thinking skills of students who have high divergent thinking skills, the maximum score of students = 96, minimum value = 70, and average = 79.72. Meanwhile, for the results of the high order thinking skill test for students who have low divergent thinking skills, the maximum score of students = 70, the minimum score of students = 20, and the average = 59.02.
Table 2. The Summary of Data High Order Thinking Skill

|                  | A1  | A2  | B1  | B2  | A1 B1 | A1 B2 | A2 B1 | A2 B2 |
|------------------|-----|-----|-----|-----|-------|-------|-------|-------|
| Average          | 74.58 | 72.50 | 79.72 | 59.02 | 71.17 | 78.00 | 71.50 | 73.33 |
| Variance         | 285.24 | 145.41 | 50.14 | 142.25 | 346.14 | 201.00 | 125.25 | 163.89 |
| Standard Deviation| 16.89 | 12.06 | 7.08 | 11.93 | 18.60 | 14.18 | 11.19 | 12.80 |
| Maximum Value    | 100  | 100  | 96  | 70  | 100  | 95  | 95  | 100  |
| Minimum Value    | 35   | 30   | 70  | 20  | 35   | 40  | 45  | 30   |

To test the normality of the data in this study used SPSS analysis Kolmogorov-Smirnov analysis test. Where a data is called normally distributed if the significance level > from the specified significance level is 0.05.

Table 3. The Normality Test with Kolmogorov-Smirnov

| No | Sampel | Statistic | Kolmogorov - Smirvon | Df | Description |
|----|--------|-----------|----------------------|----|-------------|
| 1  | A₁     | 0.080     | 60                   | Normal |
| 2  | A₂     | 0.061     | 60                   | Normal |
| 3  | B₁     | 0.099     | 60                   | Normal |
| 4  | B₂     | 0.066     | 60                   | Normal |
| 5  | A₁ B₁  | 0.338     | 30                   | Normal |
| 6  | A₁ B₂  | 0.373     | 30                   | Normal |
| 7  | A₂ B₁  | 0.265     | 30                   | Normal |
| 8  | A₂ B₂  | 0.169     | 30                   | Normal |

Based on the results of the normality analysis of the data obtained, it shows that the research data are normally distributed.

Furthermore, the homogeneity test in this study also used Levene’s SPSS test. Where a data has a homogeneous variance if the significance level > of the specified significance level is 0.05.

Table 4. The Homogeneity Test

| df | Mean Square | F | Sig |
|----|-------------|---|-----|
| 1  | 563.333     | 2.615 | 0.109 |

Based on the results of the homogeneity analysis of the data obtained, it shows that all data groups have homogeneous variants.

Based on the results of the normality test and the homogeneity of variance test, it can be concluded that the data from all groups came from a population that was normally distributed and had a homogeneous variance. Therefore, hypothesis testing with ANOVA can be done. Furthermore, if there is an interaction between the influence of the learning model of divergent thinking, then a further test is carried out using the Tukey test.

The results of this study indicate that students’ high-order thinking skills are better when using creative problem-solving models than problem-based learning models. High order thinking skills of students are also influenced by divergent thinking skills and there is also an interaction effect between learning models and divergent thinking on high order thinking skills.
The Creative Problem Solving learning model is a problem-centered learning model that emphasizes the balance between divergent thinking and convergent thinking. In addition, the Creative Problem Solving learning model can also increase students’ activities and creative thinking and think critically in the learning process [12]. During the learning process, students do not only listen and take notes. Expressing opinions, asking friends during discussions, and other activities both mentally, physically, and socially so that students can use various ways with their creative power to solve a problem.

Many factors influence the success of learning, one of which is the use of learning models. Creative problem solving is solving problems by developing their thinking by using various alternatives in solving problems. Variety of learning models that may be applied to solve problems are creative problem-solving, learning models (Creative Problem Solving Model) which are variations of Problem Solving learning by solving problems through systematic techniques in organizing creative ideas to solve problems [13]. A person’s creative way of thinking that can help solve a problem and achieve a certain goal using various ways or ideas that are not only one-way is called divergent thinking. This helps students practice higher-order thinking skills where students can analyze, evaluate and produce a new solution to the problems at hand, not just knowing and memorizing a concept. The CPS model is a learning model to solve problems creatively. According to Osborn, almost all problem-solving efforts always involve the six characteristics which are abbreviated as OFPISA: Objective, Finding, Fact Finding, Problem Finding, Solution Finding, and Acceptance Finding [14]. In addition, the teacher’s role in CPS is to direct creative problem-solving efforts. The teacher is also tasked with providing subject matter or discussion topics that can stimulate students to think creatively in solving problems [15].

Problem-based learning is one of the innovative learning models that can provide active learning conditions for students. This learning model is designed with real problems that are useful for improving students’ high-level thinking skills. The role of teachers in this model is as a facilitator so that learning is not centered on teachers but students. This problem-based learning model can develop students’ thinking processes because learning begins with giving problems to students. Students must therefore study or understand the problem to solve it. Guided by the teacher, students can solve the problem well according to their creativity and understanding so that students will gain new knowledge from their own experience.

4. Conclusion
Based on the results and discussion, it can be concluded that there are differences in high order thinking skills of students who use creative problem-solving models and students who use problem-based learning models, there are differences in high order thinking skills between students with high divergent thinking abilities and students with low divergent abilities and there is an interaction effect between learning models and divergent thinking skills to high order thinking skills.

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