Enhancing student creative thinking skills through HOTVL design

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Abstract. The purpose of this study was to investigate the creative thinking skills improvement through Higher Order Thinking Virtual Lab (HOTVL) learning. This research used a quasi-experiment method with pre- and post-test group design. 57 students took part in this research from eleventh grade student in a senior high school which is divided into two classes, experiment and control group. Student of experiment group using HOTVL experiment design and control group using lab virtual verification design. Students’ creative thinking skill was measured using tests of creative thinking skill in form of nine essay question about global warming. Learning activities in this research completed with a worksheet and lab virtual learning multimedia. This research using item response theory (IRT) to analyse the data. The result showed that the percentage of students’ latent variable (score) of creative thinking skill in HOTVL class was higher than the percentage of students’ score in lab virtual verification.

1. Introduction

Indonesia is one of the countries with low-level quality education than the other Asian countries such as Korea, Japan, Hong Kong, Malaysia, and Singapore. Based on the PISA results 2015 released in December 2016 shows that Indonesia ranked 67th from 74 participants for mathematics, 68th for reading ability, 66th for science abilities. While TIMSS result 2015 shows that Indonesia is the fourth lowest position. These results make academics especially in education feel worried about the readiness of Indonesian students toward the challenges of the 21st century. Based on the investigation from research and development of Ministry of Education about recognizing Indonesian students' weaknesses based on the TIMSS analysis results of 2015, shows that Indonesian students understand and master the questions that test the ability to remember or read available facts. But when the question asks students to combine available information/facts that occur to solve problems, Indonesian students fail [1]. In addition, the executive report from Research and Development Center of Education Ministry about, identifying the PISA Indonesia difficult questions in 2015 identified that difficult science questions for Indonesian students mostly measured the level of competence in explaining scientific phenomena and using scientific evidence [2]. Therefore learning strategies designed by the teacher should make students able to transfer knowledge received in the classroom into social problems in their environment. The fact that, it is still rarely trained, teachers focus more on training students to answer questions for exam...
preparation. However, to be able to solve social problems in this globalization era, the 21st century skills are needed. One of them is creative thinking skills.

One of science learning method that can be used to increase student creativity is practicum activities [3-5]. Based on the observations results in the field, physics teachers rarely conduct the practicum activities because the learning time is very short if they have to carry out the practicum activities. In addition, researchers also found that worksheet which is used in practicum activities only present conceptual questions and how to use the formulas.

In this study, researchers use practicum learning strategies that use virtual media that oriented to improve the student creative thinking skill. The virtual practicum is chosen because it can streamline time and provide opportunities for students to observe the things that cannot be observed directly in a real laboratory.

1.1. Theory of creativity
There is a consensus that the ability to think creatively results from a process of divergent and convergent thinking to a problem [6]. While Antink & Norman stated that creative thinking skills can be shown from the change in students’ divergent thinking [7]. According to Guilford the creative act may be regarded either as a mental or intellectual phenomenon, known as creative thinking or divergent thinking, or as a process that generates social and culture products, such as music as well as works of art, science, and technology, a concept known as divergent production [8]. From the description, it can be said that the emergence of students' creativity starts from the ability to use their higher order thinking to produce ideas (divergent and convergent thinking process) to solve a problem.

The result from the creative thinking process can be seen from some aspect, that is fluency, flexibility, originality, and elaboration [9, 10]. According to Torrance (1966, 1995), dan Guilford (1967) said that in whatever way a person understands the creative process or the production of creative outputs, one would invariably look for attributes of fluency, flexibility, originality, and elaboration [8].

A research conducted by Hu & Adey which developed a science-specific creativity test states that, the nature of creativity can be divided into four categories: creative process, creative product, creative person, creative environment [11]. However, the creative environment is out of student control, so in his research, he only uses three creative dimension models, namely creative process, creative product, creative person. Creative process consists of reasoning ability and imagination, the creative product consists of the ability to know science, the phenomenon of science, the problem of science and its technical products, a creative person consists of fluency, flexibility, and originality.

In this study, researcher focus on a creative person which divided in 4 aspects to measure creative thinking skills is fluency, flexibility, originality, and elaboration. According to Parness, fluency is the ability to produce various ideas. Flexibility is the ability to express various solutions or approaches to solve the problems. Originality is the ability to spark ideas in genuine ways. Elaboration is the ability to decipher something [12].

2. Method
This study was conducted in one of public high school in South Sulawesi. This research used a quasi-experimental method with control and experimental group design. The experimental group consisted of 28 students who study with HOTVL and Control group consisted of 29 students who study with lab virtual verification. Learning HOTVL gives the student a chance to do the experiment by them self without certain instruction but in verification class, students do the experiment by following the instruction in the worksheet.

HOTVL design in the experimental group, consisting of 10 phases of activities including real-world problems, asking experimental questions, conceptual questions, predicting, determining and evaluating ideas, exploring, measuring, analyzing, concluding, presenting. While verification lab in the control group used a design consisting of 9 stages of activities including giving purposes, delivering basic theory, providing tools and materials, giving a preliminary assignment, giving trial procedures measuring, analyzing, concluding, and end task.
The instruments in this research were creative thinking skill test in the form of nine essay question about global warming, and worksheet to view the achievement of each phase in HOTVL activities. To get the data of this study, the students’ answer was assessed by modifying the role of an assessment instrument that develops by Hu et al, who make the SSCM [11]. The fluency score is obtained simply by counting all of the true responses given by the subjects. If students’ responses consisted of variance interpretations or method, we give it 3 points; If students’ responses consisted of two interpretations or method, we give it 2 points; If students’ responses only consisted of one interpretation or method, we give it 1 point. The flexibility score for each task is obtained by counting the number of approaches or areas used in the answer. If students’ responses consisted of three concepts of physics, we give it 3 points; If students’ responses consisted of two concepts of physics, we give it 2 points; If students’ responses only consisted of one concept of physics, we give it 1 point. The originality score is developed from a tabulation of the frequency of all of the responses obtained. If the probability of a response is smaller than 5% we give it 3 points; If the probability is from 5 to 10%, we give it 2 points; If the probability of a response is greater than 10%, we give it 1 point. The elaboration score is decided by the idea or solution that given by the student. If the idea completed with the description, principle and procedure, we give it 3 points; If the idea only completed with the description without principle, and procedure, we give it 2 points; If the students only mention the idea, we give it 1 points.

The improvement of creative thinking skill analyzes with item response theory (IRT). To view the students’ ability determines by the latent variable category from DeMars [11]. The difference enhancement of creative thinking skills between HOTVL and lab virtual verification group using the calculation of t-test score, previously examined for the normality and homogeneity test.

### 3. Results and Discussions

Generally, based on the characteristic curve of the test results of the creative thinking skills of students in the HOTVL class before and after participating in the HOTVL learning model shows an improvement. Based on the percentage of latent variables (ability) in Figure.1 shows that students in the low category decreased from 47%, 13 students, to 39%, 11 students, while the percentage of students in the medium category decreased from 46%, 13 students, to 29%, 8 students, and in the high category the percentage of students greatly increased from 7%, 2 students, to 32%, 9 students. In addition, Figure.1 also shows that the post-test curve moves to the left, which means that the index of difficulty (b) decreases. This means that creative thinking skills item is relatively easier to do by students after participating in the HOTVL class.

| Ability | Category |
|---------|----------|
| $\Theta < -0.056^a$ | $\Theta < -0.31^a$ | Low |
| $0.944 > \Theta \geq -0.056$ | $0.69 > \Theta \geq -0.31$ | Medium |
| $\Theta \geq 0.944$ | $\Theta \geq 0.69$ | High |
Figure 1. Characteristic curve of students’ creative thinking skill score in HOTVL class.

Whereas, based on the characteristic curve of the test results of the creative thinking skills of students in the lab virtual verification model does not show an improvement (Figure 2). The percentage of students in the high category was reduced from 24%, 7 students for pretest were reduced to 21%, 6 students in post-test, there was 1 student who moved into the medium category. The percentage of students in the medium category is increasing from 38%, 11 students to 41%, 12 students and for low level give the same percentage before and after learning activities. Nonetheless, the graph shows the shift of the post-test curve that moves to the left, which means the index of difficulty (b) decreases. This means that the items about creative thinking skills are relatively easier for students to do after participating in practicum activities on the lab virtual verification class.

Table 2. Latent variables category in virtual verification class.

| Ability | Pretest | Post-test | Category |
|---------|---------|-----------|----------|
| θ < -0.31 | θ < 0.198 | Low |
| 0.69 > θ ≥ -0.31 | 1.198 > θ ≥ 0.198 | Medium |
| θ ≥ 0.69 | θ ≥ 1.198 | High |
Figure 2. Characteristic curve of students’ creative thinking skill score in lab virtual verification class.

The students’ creative thinking skills of HOTVL class who use the HOTVL model developed from the HOTL practice by Malik et al [13] showed an increase. Whereas for the lab virtual verification class, students’ creative thinking skills are taught using lab virtual verification models not showing improvement before and after being given treatment. This result is in line with previous research which also developed HOT Lab practicum which stated that practicum activities using HOT Lab significantly improved the creative thinking skills of physics teacher prospective students significantly compared with lab virtual verification methods [13]. These results are consistent with the results of research conducted by Fons [14] that students who are given the freedom to design their own experiments will provide opportunities for students to solve problems in a creative way. While students in the lab virtual verification practicum class do the practicum by following the procedures written in the guidebook and answering the questions presented after doing the practicum without being charged with thinking about the procedure for practicing. This has become one of the weaknesses of the lab virtual verification. The lab virtual verification only focuses on developing student competencies and topics learned but poor of training students' thinking skills [14].

The results of this study also show the achievement of students' creative thinking skills for each aspect, namely fluency, flexibility, originality, and elaboration. Based on the distribution of students' abilities (latent variables), the researcher made a comparison graph for each aspect of creative thinking skills in Figure 3.
Based on the comparison graph in HOTVL class and lab virtual verification class in Figure 3 for fluency aspect shows that the mean value of student in HOTVL class higher than students who participated in lab virtual verification class. HOTVL activities train students to think of many alternative answers when given questions in each step of the practicum activities related to the practicum that will be conducted.

For the flexibility aspect, based on the result of the mean analysis of students' creative thinking skills in Figure 3 shows that students who learn in HOTVL class have better skills to produce various ideas than students who study in lab virtual verification class. In HOTVL learning activities, students are asked to be able to determine the best idea to solve the problem (real-world problem) presented. So that students are required not only to master the concept but also be able to master the entire content so that they can see the problem from various points of view. In this step, students' creative thinking skills in the trained for flexibility aspects.

The same result for the originality aspect, based on Figure 3 shows that the skills of students taught by HOTVL model in generating new ideas (originality) better than students who are taught by lab virtual verification model. The originality aspect is the lowest value compared to other aspects. Students are still very fixated on the book or teacher's explanation when they answer the question. One cause of the indication of the phenomenon is the choice of answers in the real world problem, which makes students difficult to produce new ideas. Nevertheless, in HOTVL activities, it provides many opportunities to produce original ideas, especially at the exploration stage, where students are given the opportunity to draw up their own experiment steps and design their own lab report.

For the last aspect is an elaboration, to see the difference of achievement of HOTVL class and lab virtual verification class is shown in Figure 3 that the average of students’ ability in the HOTVL class on elaboration aspects is better than students who are practicing in the lab virtual verification class. It can happen because, in HOTVL activities students are required to provide detailed explanations at the stage of analysis and drawing the conclusions to check the correctness of predictions made at the beginning of learning.
Table 3. The normality test of students’ creative thinking skill data.

| Component                              | Sig. value | Conclusion |
|----------------------------------------|------------|------------|
| Normality of lab virtual verification class | 0.105      | Normal     |
| Normality of HOTVL class               | 0.262      | Normal     |

Table 4. The homogeneity test of students’ creative thinking skill data.

| Component | Sig. value | Conclusion |
|-----------|------------|------------|
| Homogeneity | 0.428      | Humogen    |

Table 5. The average difference test of students’ creative thinking skill data.

| Sig. Value (2-tailed)/2 | α | Status   |
|-------------------------|---|----------|
| 0.000                   | 0.05 | Ho rejected |

To answer the research hypothesis, the hypotheses were tested using classical statistical analysis on the study results. Based on Table.3 and Table.4 shows that the data is normally and homogeneously so that it is continued by testing the hypothesis using a free sample t-test. The independent sample t-test test results (Table 5) shows that Ho is rejected which means that the students’ creative thinking skill in the HOTVL class is higher than students in the lab virtual verification class. These results are consistent with previous research that virtual learning can improve the domain of creative thinking skills [15].

4. Conclusion
The implementation of HOTVL design is more effective in improving students’ creative thinking skills compared to the implementation of lab virtual verification lab design on the topic of global warming. Therefore this research was better if it continues to the other topic in physics learning.

5. References
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