The Effects of Higher Order Thinking (HOT) Laboratory Design in Hooke Law on Student’s Creative Thinking Skills

Dian Safitri1), Agus Setiawan1), Andi Suhandi1), Adam Malik1)2), Siti Ashri Sahidah Lisdiani1)1), Sapriadil1)

1)Universitas Pendidikan Indonesia, Bandung, Indonesia
2)UIN Sunan Gunung Jati, Bandung, Indonesia
3)SMAN 2 Sukabumi, Sukabumi, Indonesia

Email: dianalhamasah@gmail.com

Abstract. This research is based on a lack of creative thinking skills of students. Creative thinking as one of higher order thinking skills is urgently required by everyone to face real world problems in the 21st century. Therefore, an innovative learning method is needed to train this skill. This study aims to investigate the effect of implementation of HOT laboratory design in the topic of Hooke Law on the creative thinking skills of senior high school students in Sukabumi, West Java. It was a quasi-experimental study with non-randomized sampling technique and pre-test post-test control group design. The control group consisted of 31 students was given verification laboratory while the experimental group consisted of 30 students was given HOT laboratory. Data were collected by using creative thinking skills test and observation sheet which has been validated by expert. The finding showed that students who get HOT laboratory significantly have better creative thinking skills than students who get verification laboratory.

1. Introduction

1.1. The Important of Creative Thinking Skill in 21st Century

Globalization in the 21st century will not only have a positive impact on the welfare of individuals and society, but also cause interconnected problems and challenges. In order to live a successful life in this century, each person is required to have different skills than ever before. These skills are not really new [1]. The complex new challenges of the 21st century often require creative solutions [2].

The curriculum of education in Indonesia today, requires the creative thinking skills as one of the skills that must be achieved by the graduates [3]. The importance of creative thinking skills is also expressed by De Bono [4] that individuals need creativity to improve their quality of life, design something, solve problems, create change, and improve the efficiency and effectiveness of a system. With creative thinking skills one can succeed in learning and achieving life's success [5].

Creative thinking skills in science education, to be called precisely as scientific creativity thus have emerged as an independent field of research. Physics is a branch of natural science that studies natural phenomena or matter in the living environment of space and time, as well as all the interactions that accompany it. Physics is often referred to as the most fundamental science because every other natural science is developed by obeying the laws of physics. The subject itself has a number of potentialities within its own domain to foster creative thinking. Hence identification and subsequent nurturance of
creative talent in physics education is important [6]. The process of creative thinking imparts the ability to generate the new ideas, to realize the hidden relationships or to make a unique and modified the order among appear unrelated factors. In other words, the creative thinking is not included only one kind of treatments [7]. The abilities of creative thinking skill involved are sensitivity to problems, fluency (the ability to produce a large number of idea), flexibility (the ability to produce a variety of ideas or use a variety of approaches), originality (the ability to produce ideas that are off the beaten track), elaboration (the ability to fill in the details) and redefinition (the ability to define or perceive in a way different from the usual, established, or intended way, etc.)[8].

Given the importance of developing creative thinking skills in the 21st century hence learning in schools including school physics should refer to the 21st century educational paradigm that provides space for students to develop this skill. National Education Association [9] states that in order to students to succeed in competing in a global era then they need to have 21st century skills including creative thinking skills. Creativity should be nurtured in a socio-cultural environment. This environment includes a culture of scientific inquiry and class culture in schools, and both cultures can play a role in developing students' creative thinking [10].

The learning approach recommended by the 2013 curriculum is a scientific approach (scientific method). Activities in scientific methods invite students to observe natural events, formulate problems, formulate hypotheses, and conduct experiments to test hypotheses, draw conclusions and prepare scientific reports. These scientific activities facilitate students in trained critical thinking skills, creative thinking and communication [11]. In the subject of physics, the scientific method approach is applied in practicum activities. Laboratory activity is very important in studying science because it can improve among creative thinking skills [12]. Laboratory activities have long had a distinctive and central role in Physics curriculum, and Physics educators have suggested benefits accrued from engaging students in Physics laboratory activities[13][14]. Some design of practicum activities have been developed to improve high-order thinking skills [15][16][17][18][19].

1.2. HOT Laboratory
A recent study has developed a new design of laboratory activity namely HOT (Higher Order Thinking) Laboratory that can accommodate the improvement of creative thinking skills [20]. HOT Lab is an experiment design that train higher order thinking skills by solving real world problems through experiment steps. The subject of the research is 40 Physics Education pre-service physics teachers of UIN Sunan Gunung Jati Bandung. The findings of the study show that HOT Lab design is more effective in improving the creative thinking skills of undergraduate students than the verification lab.

The steps of the HOT Lab are composed of five general process and 11 stage activities. The processes are: 1) understand the challenges given: real world problems, 2) produce ideas: determine and evaluate ideas, 3) prepare practical activities: experimental question; (4) materials and equipment; (5) prediction; (6) question of the method, 4) carry out practical activities: exploration; (8) measurement; (9) analysis; (10) conclusion, and 5) communicate and evaluate the results of activities: presentations [21]. All those activities involve some higher order thinking skills that are proven to promote students' creative thinking skills.

Based on this background, this study was conducted to investigate the effect of implementation of HOT Lab design in the topic of Hooke Law on the creative thinking skills of senior high school students.

2. Research Hypotheses
H0: there is no significant difference in the creative thinking skill’s between students who get HOT laboratory and creative thinking skill’s students who get verification laboratory
H1: there is significant difference in the creative thinking skill’s between students who get HOT laboratory and creative thinking skill’s students who get verification laboratory
3. Research Methods
This study used quasi-experimental method with pre-test post-test control group design. The population was student from grade XI natural science of Senior High School in Sukabumi at 2016/2017 academic year. The sample was chosen by using purposive sampling technique. The control group consisted of 31 students was given verification laboratory while the experimental group consisted of 30 students was given HOT lab. The data were collected by using Creative Thinking Skills Test (CTST) in essay form which has been validated by expert and consists of three aspects, i.e. fluency, flexibility, and elaboration. To find out the improvement of creative thinking skills, it is important to analyse pre-test and post-test result from both group. It was examined by using the gain normalized \( g \). The equation to calculate the average normalized gain \( \langle g \rangle \) is presented in Equation [22].

\[
\langle g \rangle = \frac{\text{score posttest} - \text{score pretest}}{\text{score maximum} - \text{score pretest}}
\]

The calculation result \( \langle g \rangle \) is furthermore interpreted by the criteria Hake namely; \( \langle g \rangle < 0.3 \) (low); \( 0.3 \leq \langle g \rangle \leq 0.7 \) (medium); and \( \langle g \rangle > 0.7 \) (high). To examined whether there is a difference in the creative thinking skill’s between control and experiment groups, t test was used, which previously carried out test for data normality using the chi-square test and two group varians homogeneity test using the F test.

4. Finding and Discussion
At the beginning and end of the study, both experiment and control groups were asked to respond to CTST to measure their creative thinking skill. The difficulty level of post-test pre-test about CTST are as follows: easy items as much as 16.7%, medium items as much as 50%, and difficult items as much as 33%. Score, mean, and standard deviation of pretest and posttest scores were calculated. N-gain was employed to compare the groups' mean. The results obtained are shown in Table 1.

| Description       | Experimental group | Control group |
|-------------------|--------------------|---------------|
|                   | Pre-test           | Post-test     | Pre-test     | Post-test     |
| Maximum score     | 18                 | 28            | 17           | 23            |
| Minimum score     | 5                  | 18            | 4            | 12            |
| Average score     | 11.4               | 21.0          | 11.1         | 17.6          |
| Standard deviation| 3.2                | 2.5           | 3.7          | 3.2           |
| Varian            | 10.9               | 6.1           | 14.5         | 10.2          |
| N-gain            | 0.59               | 0.35          |

Based on Table 1, it can be observed that after implementation HOT Lab; there is an increasing in student’s creative thinking skills in both of group in medium category. But the improvement of creative thinking skills of the experimental group is higher than that of the control group. It is confirmed by the N-gain obtained by experimental group of about 0.59 while N-gain obtained by control group of about 0.35.

In this study also obtained N-gain score of creative thinking skills aspect as shown in Figure 1. Based on figure 1, it is known that there is an increasing of creative thinking skill in all aspect. In both group, the highest increasing is fluency aspect and the lowest is elaboration aspect. But in each aspect, the increase in the experimental group was higher than in the control group.
Figure 1. The Increase of Creative Thinking Skills in Each Aspect

For the fluency aspect, the increase in experiment group higher than control group. For the fluency aspect, the improvements achieved by the experimental group were higher which in high category than the control group which in medium category. This is because students who get HOT Lab in experimental groups are better trained in demonstrating skills to evaluate some relevant ideas. The students in the control group are poorly trained to find out the ideas to solve solutions because they only verify existing concepts. For aspect flexibility, an increase in both groups including the medium category but the experimental group achieved a higher increase than the control group. In the HOT Lab steps students are trained to be able to see the problem from a different point of view, because in the real world problem stage, it’s given some alternative problem solving ideas that should be analyzed and evaluated by the students. To evaluate each of these ideas, provided several different kinds of springs and how to arrange them. Students must analyze these ideas and decide the right idea to solve the problem. However, the experiments conducted in this study are still limited in frequency so that the students' fluency skill has not been trained optimally. While in verification practice, activity steps and tools and materials have been given by the teacher so that students are not trained to be able to see the problem from different point of view. The improvement of elaboration aspect in the experimental group is included in the medium category, but in the control category, including the low category. At the HOT Lab step students are trained to develop existing information for the new context and carry out detailed problem-solving steps. While on the verification lab students are not introduced to real world problems about Hooke’s law and alternative solutions, students do not plan experimental activities and they can quickly find out what procedures or steps should be ignored without understanding the overall procedure, so that students are not trained to elaborate ideas.

Before examined the research hypothesis, a prerequisite test of the research was conducted. The results show that the data of N-gain of both groups are normal and the data varians of two groups was homogeneous at the 0.05 significance level. The data varians for two group is homogeneous and normally distributed data, so the hypotheses test is performed by using two tile-t test. Table 2 analysis between control and experimental groups is shown in Table 2. It revealed that at 5% level of significance, the t-table is 1.67 while the t-calculation is 7.27. According Table 2, we decide reject the null hypothesis and receive alternative hypothesis stating that there is significant difference in the creative thinking skill’s between students who get HOT laboratory and creative thinking skill’s students who get verification laboratory. The results of this study are in line with the results of research conducted by Malik et al [22], that the implementation of HOT Lab design can significantly increase student’s creative thinking skill compared with the implementation of verification laboratory.
Table 2. t-test analysis between control and experimental groups

| Group   | N-Gain | N | dk | t-cal | t-table |
|---------|--------|---|----|-------|---------|
| Control | 0.35   | 31 | 59 | 7.27  | 1.67    |
| Experiment | 0.59   | 30 |     |       |         |

5. Conclusion

Based on the results of research and discussion, show that the application of HOT Lab can further improve creative thinking skills of student’s senior high school on Hooke Law compared to the application of laboratory verification. HOT Lab can be applied to several other physics topics provided that the concept can be practiced in real laboratory or through virtual lab.

Acknowledgment

The author would like to thank Mr. Marpudin, S.Pd and MM.Pd who has given permission and support in research at SMAN 2 Sukabumi. Also to Fasal Elahi, M.Pis for moral and material support so that this research can be completed properly. And to all students of SMAN 2 Sukabumi who helped and support in this research.

References

[1] Rotherham A J and Willingham D 2009 21st Century Skills: The Challenges Ahead;In Teaching for the 21st Century Educational Leadership 67 1 16-21
[2] Tromp H C 2016 Facilitating creative thinking in the 21st century: When constraints help; In Creative Intelligence in the 21st Century: Grappling with Enormous Problems and Huge Opportunities(Rotterdam, The Netherlands: Sense Publishers) p 107-117
[3] Kemendikbud 2013 Attachment regulation of the minister of education and culture no 54 year 2013 (Indonesia: Kemendikbud)
[4] McGregor D 2007 Developing Thinking Developing Learning Open University Press
[5] Fisher R 2006 Expanding Minds: Developing Creative Thinking in Young Learners. CATS: The IATEFL YLSIG. J. 5-9
[6] Mukhopadhyay R 2013 Measurement of Creativity in Physics - A Brief Review on Related ToolsIOSR-JHSS 6 545-50
[7] Piaw C Y (2010) Building a test to assess creative and critical thinking simultaneously. Proc. Soc. and Behav. Scie. 2551-559
[8] Torrance E P1977 Creativity in the Classroom: What Research Says to the Teacher (Washington DC: ERIC) p 17
[9] National Education Association (NEA) 2012 Preparing 21st Century Students for a Global Society: An Educator’s Guide to the “Four Cs”. http://www.nea.org/assets/docs/A-Guide-to-Four-Cs.pdf
[10] Hadziigeorgiou Y, Fokialis P, Kabouropulou 2012 Thinking about creativity in science education. Scie. Research 3
[11] Kemendikbud 2013 Appendix Permendikbud No 64 Year 2013: http://www.bsnp-indonesia.org/id/wp-content/uploads/2009/06/Permendikbud-Nomor-64-tahun-2013-ttg-SI.pdf
[12] Deacona C and Hajek A 2010 Student Perceptions of the Value of Physics Laboratories. Int. J. of Scie. Educ. 1-35

[13] Hofstein S and Lunetta V N 2004 The Laboratory in Science Education : Foundation for The Twenty first Century. Scie. Educ. 88 1 28-54
[14] Burke K A, Thomas J G, and Brian MH 2006 Implementing the Physics Writing
[15] Heller P and Heller K 1999 Cooperative Group Problem Solving in Physics (Universitas Minesota) p 125

[16] Wenning C J 2011 The Levels of Inquiry of Model Science Teaching J. Phys. Teach. Educ. 6 2 p 9-16

[17] Ojediran I A, Oludipe D I, Ehindero O J 2014 Impact of Laboratory-Based Instructional Intervention on the Learning Outcomes of Low Performing Senior Secondary Students in Physics Creat. Educ. 5 197-206

[18] Busyairi A 2015 Penerapan Strategi Pembelajaran Creative Problem Solving Berbasis Eksperimen Dalam Pembelajaran Fisika Untuk Meningkatkan Kemampuan Kognitif dan Keterampilan Berpikir Kreatif Dalam Menyelesaikan Masalah Siswa SMA pada Materi Listrik Dinamis Tesis UPI : Tidak diterbitkan

[19] Prima E C and Ferranie S 2016 Problem solving laboratory as an Alternative physics experiment activity Model implemented in senior high School. https://www.researchgate.net/publication/265080312

[20] Malik A and Setiawan A 2016 Proc.of the 2015 Int. Conf. on Innovation in Engineering and Vocational Education: The development of higher order thinking laboratory to improve transferable skills of students (Yogyakarta: Atlantis Press) 56 36–40

[21] Malik A et al 2017 Proc. of AIP Conference Proceedings: Enhancing pre-service physics teachers’ creative thinking skills through HOT lab design (Manado: American Institute of Physics)