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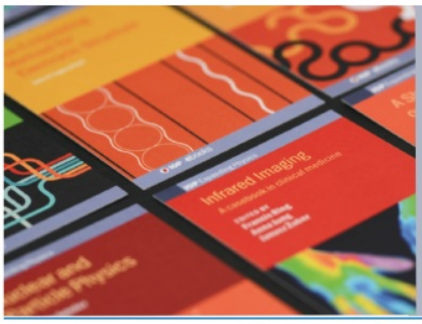

Using Virtual Laboratory to Improve Pre-service Physics Teachers' Creativity and Problem-Solving Skills on Thermodynamics Concept

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Abstract. Virtual laboratories have been developed in this study as an alternative to the limited equipment of physi experiments. This study aims to examine the effectiveness of virtual lab models to improve creativity and problem-solving skills for spective physics teachers. The research and development have been divided into 3 phases namely, preliminary study, design development, and model testing. Model testing was performed on two groups of thermodynamic courses using a pre-test post-test control group design. The instruments that have been used are cr vity tests and problem-solving tests in the form of essays. Instruments of creativity include verbal and figural aspects. Each data was analyzed using t t and normalized gain score. The results showed that there was increase in creativity and problem-solving skills in both groups. T creativity of students of the experimental group was higher than the control group. Student problem-solving skills in the two groups differed significantly. The experimental group has a higher problem-solving ability than t control group. This suggested that the developed virtual lab model proved to improve the creativity and problem-solving skills ability of prospective physics teachers.

1. Introduction

Physics is a part of science that consists of facts, concepts, principles and laws that are verified through a set of experimental activities and quantitative measurements. One of the goals of physics learning is to develop theories to create technology that is capable of assisting human life. Thus, learning physics plays an essential role in educating, cultivating, and developing the potential of learners to becom qualified human resources. Afrizon et al. [1] stated that physics learning had contributed a lot to the development of science and technology. Most of the technology used by humans today based on the development of theories of physics.

One of the branches of physics is thermodynamics. Thermodynamics consists of abstract concepts that learn about the relationship between energy and work of a system. Thermodynamics also studies the macroscopic quantities of systems that can be observed and measured in experiments. Microscopic quantities of thermodynamics can be studied in the gases kinetic theory. The concept and theory of thermodynamics have developed many industrial and technological systems in the world. Without

studying thermodynamics well, maybe at this moment, we cannot enjoy the advanced technology that helps our lives.

Learning on thermodynamic concepts needs to be supported by adequate experimental activities to examine the truth and to develop the thermodynamic theories. Experimental activities provide an opportunity for learners to discover their concepts through observation with thinking skills, creativity, and problem-solving skills. Currently, the implementation of experimental activities encountered many obstacles such as laboratory facilities, and infrastructure does not support the experimental activities. In addition, some experimental activities also require a high cost and take a long time to experiment with results as expected. This problem then becomes the main reason why experimental activities are not conducted by educators, thus implicating the low creativity and problem-solving skills of students.

Some of these problems can be solved by developing innovative learning media. The use of supporting media can make learning more productive and able to simplify complex concepts. Many media can be used in physics learning, especially in thermodynamics course. Currently, computer-based media is considered the most appropriate to use. Computer-based media can make students get unlimited information. One of the computer-based media that can support the experimental activity is a virtual laboratory.

A virtual laboratory developed and used to perform experimental activities just like a real laboratory. The virtual laboratory can display text, sound, graphics, video, and animation in an interactive view oriented toward solving real-world problems. Interactive animation such as sub-microscopic media could help students to understand the abstract concept [2]. The virtual laboratory is more accessible for learners to review specific sections and explore ideas more deeply in experimental activities [3]. Experiment activity with virtual laboratory also offers efficiency and help students to experiment repeatedly [4] as well as in real laboratories [5].

One of the aims of learning is to improve students' learning achievement. The current learning process is expected to improve student learning outcomes such as creativity and problem-solving abilities. Problem solving and creativity are essential skills, especially in technology development. Creativity and problem-solving skills are high-level thinking skills that learners need to have to compete in the global competition. Creativity is the ability to discover new things but still in rational ideas. Creativity can help us to do things better. Therefore, everyone needs to act creatively. According to Jackson et al. [6], creativity was defined as a mental process involving the generation of new ideas and new concepts, or new associations between ideas or concepts. From a scientific point of view, the product of creative thinking is usually considered to have originality and conformity. Kandiko [7] reported that creativity is a spontaneous but rational individual action.

In addition to creativity, problem-solving skills are also the most necessary capabilities for the advancement of the younger generation. A person with a reasonable level of problem-solving ability will be able to process information more effectively for his life. Coşkun et al. [8] stated that people who have excellent problem-solving skills could have a better life than others because they are more successful in finding the best solution and knowing how to behave in a problem situation. According to Al-khatib [9], creative thinking ability, especially creative problem solving is essential because it can help someone to face technological change and interact in the globalization era.

Innovation learning media such as virtual laboratory is expected to improve student learning outcomes. Several studies about the use of virtual laboratories have shown a positive impact on learning outcomes. Gunawan et al. [10] revealed that the use of virtual laboratory media could improve the students' conceptual understanding in three different schools. According to Oidov et al. [11], a virtual laboratory contributes to learning, which motivates learners in activities to discover new things so that the learning results also increased. According to Gunawan et al. [12], a virtual laboratory can improve the problem-solving ability of students on the electricity concept. Tüysüz [13] revealed that the use of virtual laboratories could have a positive impact on student learning achievement. Therefore, this study aims to examine the model of the thermodynamic virtual laboratory that has been developed in improving the creativity and problem-solving skills of the pre-service physics teachers.

2. Methods

This research includes development research with three stages namely preliminary study, design development, and testing model. In this research has developed a virtual laboratory for thermodynamics course. Model testing was performed on two groups of students of FKIP Universitas Mataram who were following the thermodynamics course by using a pre-test post-test control group design. The sample was chosen by purposive sampling. The experimental group was treated with the use of virtual laboratory learning model while the control group with conventional learning. The instrument used is the essay test both for creativity and problem-solving ability. The experts have validated the instruments. Creativity instruments include verbal and figural aspects. Each data was analyzed using the t-test. Improved problem-solving skills and prospective physics teacher creativity have been measured using the N-gain formula. N-gain has been used to avoid misinterpretation of increasing scores of each prospective teacher.

3. Results and Discussion

This research used a virtual laboratory to enhance the creativity and problem-solving skills of pre-service physics teachers on thermodynamics course. Creativity and problem-solving skill are part of the high order thinking skill that became the primary goal of education in this century. In this study used experimental groups and control groups to examine the effect of the use of virtual laboratories. The experimental group was treated in the use of virtual laboratory while the control group was treated in the conventional learning. Before treatment, both groups of samples were given pre-test of thermodynamic course. The results showed that both groups have the same ability. After treatment, both groups were given a final test to determine the effect of the thermodynamic virtual laboratory. Furthermore, to reduce misinterpretation of student creativity improvement, N-gain test is also performed. Hypothesis test results on creativity data of both groups are shown in Table 1.

Table 1. Hypothesis Test Results of Creativity in Both Sample Groups.

Mann-Witney	Sig.	Interpretation
Pre-test	.163	There was no initial creativity difference between the two sample groups
Post-test	.036	There was a final creativity difference between the two sample groups
Verbal N-gain	.111	There was no difference in N-gain of verbal creativity between the two sample groups
Figural N-gain	.993	There was no difference in N-gain of figural creativity between the two sample groups
Total N-gain	.167	There was no difference in N-gain creativity between the two sample groups

Based on the data in Table 1, statistically, pre-test data showed that there was no initial creativity difference between the two groups. This means that the level of creativity that students have in both groups is the same. In the post-test, there was a creativity difference between the two groups, in which the experimental group scored higher than the control group. The improvement of creativity of experimental group and control group was not significantly different. Nevertheless, it can conclude that the virtual laboratory used is better enough to develop students' creativity. The results of the study, Gunawan et al. [14] reported that virtual physics laboratories used in cooperative learning could enhance students' creativity, especially on fluency and elaboration indicators. The increase of verbal and figural creativity in both groups was not statistically significant. Comparison of N-gain verbal, N-gain figural, and total N-gain between experimental and control groups are shown in Figure 1.

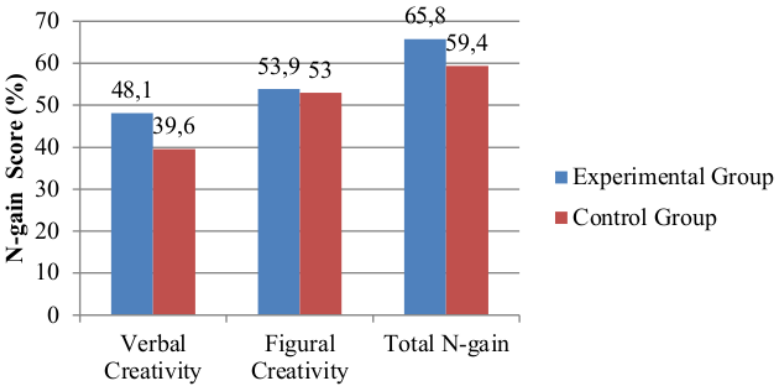

Figure 1. Comparison of Verbal and Figural Creativity in Both Sample Groups

Based on Figure 1 it can be seen that the verbal N-gain of the experimental group is higher than the control group. Therefore, students who have learning with virtual laboratory has sufficiently able to associate their ideas through verbal communication. For the improvement of figural creativity, the experimental and control groups had relatively similar improvements, classified as in the medium category. The data shows that both groups have the same ability to pour ideas through graphs, images, and patterns.

In the experimental group, the acquisition of increased verbal creativity was lower than figural creativity, i.e., 48.1% for verbal creativity and 53.9% for figural creativity. The data showed that the ability of students in pouring ideas through pictures or graphics are better than through verbal communication. Some of the things that are assumed to be the cause of this acquisition are as follows. The virtual laboratory used in this study consist of symbols and images. Also, thermodynamic materials also emphasize much on the graphics that students must understand. The figural creativity of students is better because of this habituation. Students ability to create ideas through graphics and images to be higher than pouring their ideas in verbal. In another study, Gunawan et al. [15] revealed that the project-based learning model with virtual media could improve students' thinking skills in aspects related to fluency, flexibility, and originality rather than ideas associated with patterns or images. In addition, Gunawan et al. [16] stated that virtual laboratories could help students develop their thinking skills by combining ideas verbally. It caused the improvement of verbal creativity was higher than figural creativity.

The use of virtual laboratories in this study has had a positive impact on students' thermodynamic learning. The use of virtual laboratories in thermodynamic learning has been proven to help students overcome the difficulties they face in learning and improve their creativity. For example, the difficulty of graphics can be overcome by visualizing graphs and physical variables, such as isobaric, isochoric, isothermic, and adiabatic graphics. Some of the interactive simulations contained in this model also give students an excellent opportunity to learn to make estimates and try to prove for themselves the truth of their estimates. This condition causes students' figural creativity to be higher than verbal creativity. According to Gunawan et al. [17], a laboratory used in electrical concept can significantly enhance students' creativity in verbal and figural aspects.

This study has also examined the effect of virtual laboratory use on problem-solving skills of pre-service physics teachers. Problem-solving ability is one of the higher-order thinking and complex thinking skills that a person can achieve when understanding concepts well. The results of a hypothesis test of problem-solving ability data are shown in Table 2.

Table 2. Hypothesis Test Result of Problem-Solving Ability Data

Mann-Witney	Sig.	Interpretation
Pre-Test	.248	There was no difference in problem-solving skill between the two sample groups
Post-Test	.001	There was a difference between problem-solving skill between the two sample groups
N-gain	.001	There was a difference between N-gain problem-solving skill between the two sample groups

The pre-test hypothesis test showed that there was no difference in students' initial problem-solving skills because students have not received learning and only use the initial knowledge to solve the problem. After being treated, the results of the problem-solving tests of both groups increased. The test results of both groups were statistically significantly different. The experimental group had a significantly higher score than the control group. These results have proven that virtual laboratories have successfully improved students' problem-solving skills. The results of this study have supported previous studies by Oidov et al. [11] who found that virtual experimental activity has helped students perform numerical measurements, evaluating the processes being explored and developing problem-solving skills. Gunawan et al. [18] stated that the virtual laboratory help students to identify the problem and make a plan in solving the problem excellently. In this study, the improved of the problem-solving abilities of pre-service physics teachers are analyzed. Figure 2 shows the results of the pre-test, post-test, and N-gain scores in both groups.

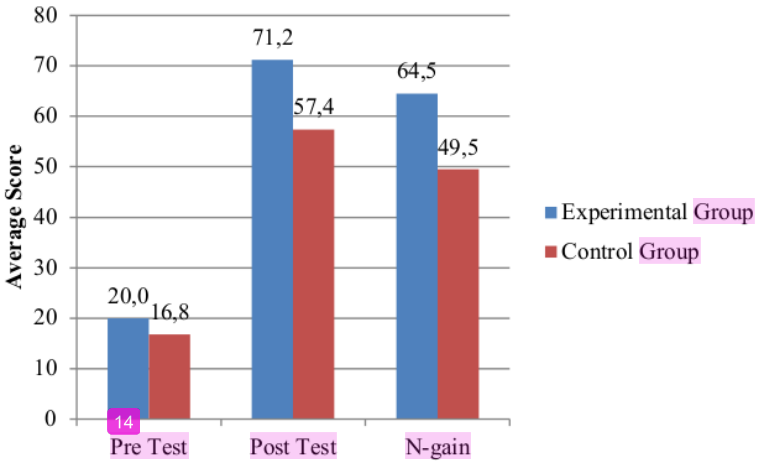

Figure 2. Comparison of Students' Problem-Solving Skill in Both Sample Groups

Based on Figure 2, it can be seen that the increase in the experimental group was significantly higher than the control group. Students' problem-solving abilities are proven to be improved through thermodynamic learning with virtual laboratories. According to Herga & Dinevski [19], the use of virtual labs has supported high-level thinking skills, including problem-solving skills. Virtual laboratories can present animation effectively to teach and visualize abstract concepts or difficult things in science [20]. When students have understood the concept of thermodynamics well, problem-solving abilities will also increase. Virtual laboratories can enhance students' understanding of the

basic concepts of data analysis, problem solving, scientific interpretation [21], numerical concept, and verbal communication [22].

Problem-solving skills in physics require the interpretation and application of one or more types of representation, such as algebra, graphics, and numerical [23]. Thermodynamic learning emphasizes abstract concepts that require visualization in the form of graphs and physical variables. The virtual laboratory on thermodynamic concepts clarifies experimental aspects and graphical visualization. Therefore, this virtual laboratory has been able to support students' ability in solving thermodynamic problems that contain many mathematical equations. Paszkiel [24] revealed that virtual media had transformed the real environment into meaningful images in mathematical calculations. Shyr [25] has reported that virtual laboratories allow students to develop their programs and identify problems related to their implementation. This advantage supports the development of problem-solving skills from pre-service physics teachers in thermodynamic courses.

4. Conclusion

Based on the results of data analysis and discussion it can be concluded that the use of virtual laboratories in learning the concept of thermodynamics has been able to increase the creativity and problem-solving skills of physics teacher candidates. Student creativity in the experimental group was higher than the control group, although the difference was not significantly different. Enhancement of creativity in both groups was in the moderate category. Meanwhile, the problem-solving ability of the experimental group was significantly higher than the control group. The results of this study have proven that the use of virtual laboratory on learning the concept of thermodynamics can improve creativity and problem-solving skills of physics teacher candidates. These results also reinforce previous research on the importance of the role of information technology to improve the thinking skills of prospective teachers.

The recommendations that can be given for further research are: (a) The need to familiarize users with the features of the virtual lab program before the research process is carried out. (b) The need for assistance by technicians and research staff, especially at the initial meetings, given the many technical constraints due to the diverse abilities of students. (3) Problems related to the implementation time of learning that must be tightly controlled so that learning takes place by the plans and objectives set.

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