Momentum: Physics Education Journal

The mastery of physics concepts between students are learning by ICT and laboratory experiments based-teaching

Drikben Eka Putra Nggadas*, Ariswan
Universitas Negeri Yogyakarta, Indonesia
*Corresponding author, e-mail: drikbennggadas@ymail.com

Abstract: The study aimed to examine differences in the mastery of physics concepts between students are learning by ICT based-teaching and laboratory experiments based-teaching. The particular research was quasi-experiment with a pretest-posttest design with nonequivalent groups. The sample size was three classes selected from the population of students on class X of SMA N 4 Kupang. The data collection method used multiple choice questions tests. Data analysis used independent samples t-test using SPSS 16.0 for Windows. The results of data analysis using t-test at a significance level of 0.05 indicated that there was a difference in the average mastery of physics concepts between students are learning by ICT based-teaching and the laboratory experiments based-teaching. The mean score of the mastery of physics concept on students are learning by ICT based-teaching was higher than students are learning by laboratory experiments based-teaching.

Key Words: mastery concepts; ICT based-teaching; laboratory experiments based-teaching

1. Introduction

Good education very depends on a variety of important things such as the available resource of a teacher with expertise, the availability of supporting infrastructure for educational activities, and the support or concern of the government and the community towards improving the quality of education. The quality of good education based on the National Education System, Law No. 20 of 2003 article 2 and 3, is able to form a dignified character and national civilization in order to educate the nation's life, developing the potential of students to have faith to god the almighty, moral noble, healthy, knowledge, capable, creative, independent, and democratic and responsible people. This mandate is the responsibility of the government as policymakers aiming to achieve the national goals of education and improve the quality of education as well as the quality of human resources to involve in globalization era (2003: p .5).

To improve the quality of education among Indonesian people in globalization, then each education unit or school has the responsibility to prepare the students to be ready involving into community life. Schools are required to be able to compete globally. In the scope of preparing and improving the education quality of the students, schools are permitted to develop the curriculums in accordance with regional potential. Therefore, local governments play a very important role in assuring the quality of education in the effort to achieve national education goals in Indonesia. However, the reality occurs in reality that local government had not given maximal attention and the educational institutions/schools.

Not surprisingly, there is always issue at every end of the academic year which blames the low quality of education at all types and levels of education, especially primary and secondary education. The demands of graduation standards are a problem for teachers, institutions and the educational environment

because a few students do not pass the National Examination. Almost all regions in Indonesia have the same problem, including in Nusa Tenggara Timur (NTT) Province which for two consecutive years; 2010/2011 and 2011/2012 academic year, the percentage of failed on the National Examination at High School in NTT is on the first of 33 provinces in Indonesia. In fact, the provincial government has shown the efforts to guarantee and improve the quality of education in all districts/cities through various policies such as the procurement of infrastructure and supporting facilities, as well as providing tutor programs. But, the results have not shown as expected.

Physic is a subject with a high number of failed in passing the exam at the level of Senior High School (SMA) and considered as difficult by students. The phenomenon is caused by the conventional learning of physics in the classroom which might prioritize in memorizing the formulas and completes the questions. In fact, physics have many and various formulas, but the students rely on their memorizing formulas to answer questions without understanding the concept of the formula. Meanwhile, according to Mundilarto (2013: p.250), learning physics is not only just memorize the theories, laws, postulates, and formulas. Therefore, Hamalik (2010: p.33), educators/teachers must create a pleasant atmosphere in learning activities aiming to form the conceptualization within students. Teachers also need to choose and use the teaching methods and learning media to create conditions of learning activities that provide students the freedom to think, assume, and master the concepts.

To master the concept of physics, the teacher needs to always motivate the students to have achievement through the learning process and provide an environment which able to supports the creation of an atmosphere as young scientists (Sumardjoko, 2010: p.300). The atmosphere as a young scientist can be done in the laboratory through experimental activities. Students can perform activities in the laboratory as young scientists by explaining and trying to understand the physics concepts. Mundilarto (2002: p.348) stated that the purpose of physics education is related to laboratory activities such as observation, measurement, using the experimental equipment, etc. The approach in physics learning aims to lead the students to find concepts and principles of physics through designed experiments and then discuss them with fellow friends and teachers. Also, Sagala (2010: p.220) stated that the role of the teacher in an experiment was very important relating to accuracy and fidelity to minimize or zero mistakes and errors in interpreting and concluding the experiment.

Dynamic electrical material is a topic or material of physics which needs varies learning media its implementation. The mastery of the concept of dynamic electrical material is through practical activities directly in the laboratory. The practicum can explain to students about what is learned with the actual conditions occur in everyday life and facilitate the students to have better knowledge or understand and master the concept of dynamic electricity that they gained from teachers or other learning resources. The concept of dynamic electricity might also be learned through communication information technology facilities/media such as animation or computer simulation. The experiments in the laboratory can be simulated with a computer simulation, and the observations or investigations can perform easily and quickly.

The physics concepts might be packaged into a computer simulation to bring students in conditions as young scientists. Using technology (computer simulation media), students might not have to direct experiments inside the laboratory, but they can feel the atmosphere/situation like a scientist when interpreting the simulation properly. In physics learning, there are certain topics that might not be seen in real (only imaginable), too fast to observe, require a long time in observation; in solve those problems, technology is required to visualize the conditions which might not probably perform through a practicum in the laboratory.

The selection of good and varied methods, media and learning resources in physics learning must perform by teachers with full innovation to motivate and instill the physics concepts to the students. The fact found in Kupang (NTT); the teacher still emphasized the students how to solve the physics problems

because they anticipated the problem of graduation rates in the area of Kupang. In fact, teachers should emphasize the learning in mastering the physics concepts through interesting and fun learning activities for students aiming the physics concepts are embedded in their memories for a longer time. Various uses of laboratory and technology will make the students more energetic and motivated to learn physics. Meanwhile, Peerer & van Petegem (2009: p.1) stated that one of the obstacles to integrating technology in learning is teacher skill. Therefore, physics teachers are not only required to understand the physics teaching and use the laboratories as a means and media, but they are also required to be creative and innovate in using technology into physics learning.

The local government of Kupang has shown the best effort to solve the problem, including building laboratories, completing the laboratory equipment and technology for schools. However, the graduation rate of high school / Islamic school is still low. Kupang as the capital city of the province is still low compared to other districts in terms of graduation rates. Based on data of facilities of High School / Islamic high school in 2011/2012 in Kupang, there were 31 senior high schools/ Islamic high school with 12,892 students. But, there are only 21 schools having physics laboratories, 17 schools having computer laboratories, and 9 schools having a multimedia laboratory. These facilities are very lacking compared to the number of schools and students of High School / Islamic High School in in the Kupang City.

Based on the data, the infrastructure supporting physics learning is still low, such as physics laboratories, computer laboratories, and multimedia laboratories. In fact, physics learning in the laboratory will provide learning experiences to students directly, and provide the student to have meaningful learning. Laboratory activities can also improve the process skills of students to motivate the student to learn independently and the concepts might be well accepted and mastered. For a certain time, the management of school laboratories has not performed well, even impressed the laboratory is not functioning as expected because the teacher is less using it with the reasons for insufficient study hours.

The facts occur in the field; it is not optimal in laboratory use and there is a shift in the function of the laboratory into classrooms or warehouses. In the other hand, the use of laboratories will provide meaningful learning for students, in line with Hamid (2004: p.57) stated that the students will be familiar to conduct scientific processes. As the impact, the students obtain scientific products and scientific attitudes, and finally, students are expected to communicate the results to other parties and apply in daily life. Suryadi (2007) suggests that using technology in the learning process undoubtedly has advantages, such simplifying and accelerating the student work (efficient), and also involve the students into fun learning because they interact with colors, images, sounds, videos, and instant things. The pleasant situations and conditions are actually very important and essential factors in achieving the learning effectiveness.

The responsibility of the school is to prepare the students to face all the challenges that change very rapidly in society. In this case, the schools are required to produce a good Human Resources (HR) which has the capability to involve in global competition. The government through the Ministry of National Education issued PERMENDIKNAS (National Education Regulation) No. 38 of 2008 on the management and using the communication information technology in learning (2008: p.1) aiming to support the distribution. Improving the quality and abilities of students might be done easily by using the internet as a means to access knowledge. The effort can be done by using communication information technology as an approach to the learning process at schools.

The world of education has benefited greatly from the advancement of information technology communication because of the tremendous benefits. It is a time for educational institutions or school to immediately introduce and begin the use the technology as a more up-to-date learning base (Hamdani, 2011: p.243). In line with the demands in PP (Government Regulation) RI No. 19 of 2005 on National Education Standards which states that, the learning process in educational units is held interactively, inspirational, fun, challenging, motivating students to actively participate, and providing sufficient space for

initiatives, creativity, and independence in accordance with their talents, interests and physical and psychological development of students.

Implementing a good learning activity will make the students mastering the concepts of the lessons learned. In this case, educators or teacher play an important role in supporting and improving the mastery of students' concepts. Teachers or educators are required to present learning that frees the students to think and assuming according to the development of students and the environment. The good learning is by choosing and using an appropriate teaching and learning methods and learning media to the material and create an active, creative, effective and enjoyable learning atmosphere. The teacher has a big responsibility and should create a fun learning program for the students. Sagala stated the learning continues to develop in line with the development of science and technology. So, it is not sufficient if the source of learning comes from teachers and textbook. It needs a new way of communicating the teaching material in a separated or structured system (2010: p.166). Using technology in physics such as animation and computer simulation is a way to make physics learning fun and popular with students and the concepts can be mastered well.

The problem formulation proposed in this study is how much the difference in the mastery of physics concepts between students are learning by ICT based-teaching and laboratory experiments based-teaching. The study aimed to examine the differences in the mastery of physics concepts between students are learning by ICT based-teaching and laboratory experiments based-teaching. Meanwhile, the definition of operational variables in this study is; mastery the physics concept is the physics cognitive abilities of students consisting of memory, understanding, application, analysis, synthesis, and evaluation. ICT-based learning is learning with investigations through simulation of physics experiments with the computer. Laboratory experiments based-teaching is learning by conducting investigations through experiments in the laboratory.

2. Methods

The research was a quantitative study with a quasi-experiment method. In a quasi-experiment, the research subjects were not randomly selected but used all the group subject. This research aimed to determine the effect and compare the influence of ICT-based learning and laboratory experiments on students' mastery the physics concepts. Then, there were three groups of students in particular research, namely three classes or three study groups.

The research design was a pretest-posttest with a nonequivalent group. Three research classes obtained different treatments; first group (experimental class I) treated with communication information technology (ICT) based learning, second group (experimental class II) treated with laboratory experiment based-teaching, and third groups (control class) treated with a conventional method. This design presented in table 1.

The research conducted in class X of SMA 4 Kupang, Nusa Tenggara Timur Province. The research was conducted in April to June on even semester 2012/2013 Academic Year and conducting during physics class. Then, the research did not interfere with the learning process at school.

The population in the particular study was all students on science class of Class X SMA 4 Kupang in the academic year 2012/2013. And, the research sample was three classes selected from the population with a cluster random sampling technique.

The variables consisted of independent variables, dependent variables, and control variables. The independent variable was physics learning using ICT-based learning in the experimental class I, laboratory experiment based-teaching in the experimental class II, and conventional learning in the control class. The dependent variable was the students' mastery of physical concepts. Meanwhile, the controlled variable in this study is the initial ability of the experimental group and the control group to have the same variance, the same teacher, the same of study hours, and the same subject material.

Tabel 1. Research Design

Group	Pretest	Treatment	Posttest
Experiment I	T_1	X_1	T_2
Experiment II	T_1	X_2	T_2
Control	T_1	-	T_2

Where:

T_1 : *pretest*

T_2 : *posttest*

X_1 : Treatment with ICT-based learning

X_2 : Treatment with laboratory experiment based-teaching

X_3 : Conventional learning

Data collection techniques used written tests to obtain data on the effect of learning on students' mastery of physics concepts. The written test technique used to measure the mastery of students' physical concepts. The test carried out twice; before treatment (pretest) and after treatment (posttest). The test in the study was multiple choice tests.

The research instruments were in line with data collection techniques, which are the multiple choice questions to measure the students' mastery of physics concepts based on the material provided during treatment with five alternative answers.

Validity test used iteman version 3.00. Item quality is assessed from at least two criteria or two parameters, namely (a) item difficulty index and (b) item differentiation power, and also distractor effectiveness. The validity coefficient of satisfactory when the score exceeds rxy = 0.30 (Sugiyono, 2013: 134).

An instrument is stated as reliable when the instrument has the same results on repeating measurements for many times. The reliability coefficient of multiple choice test instrument used Kuder Richardson (KR20) formula, namely:

$$r_{11} = \left(\frac{n}{n-1}\right)\left(\frac{s_t^2 - \sum pq}{s_t^2}\right)$$

Where:

n = number of items in the instrument

p = the proportion of students who answered correctly on each item

q = 1 – p

s_t = total variance

The data obtained from the instrument analyzed using descriptive analysis and statistical analysis. The results of descriptive statistics interpreted in the form of mean, median, mode, standard deviation, variance, minimum value, and maximum value. The calculation of descriptive statistics used SPSS 16 for Windows. The statistical analysis was performed to test the research hypothesis using t-test. However, normality test and homogeneity test conducted on the prerequisite test.

Hypothesis test used to test whether ICT-based learning is better than laboratory experiment based-learning in improving the students' mastery of physics concepts or laboratory experiment based- learning is better than ICT-based learning in improving the students' mastery of physics concepts.

The formulations of the hypothesis are:

H_0; There is no significant difference in the average of students' mastery of physics concepts between students are learning by ICT based-teaching and laboratory experiments based-teaching.

H_a; there is significant difference in the average of students' mastery of physics concepts between students are learning by ICT based-teaching and laboratory experiments based-teaching.

The hypothesis test was analyzed using SPSS 16 for windows with the statistics test of independent sample t-test. The criteria in the independent sample t-test with a significance level of 5% are:

H_0 accepted if the significance > 0.05

H_0 rejected if the significance ≤ 0.05

If H_0 rejected, then it continued by comparing the mean or higher between the two hypotheses.

3. Results and Discussions

Analysis results the initial ability of the sample using the Kolmogorov-Smirnov test and the Levene test found out that the three samples group have relatively homogeneous variances and normally distributed. In sum, the samples group fulfilled the requirements as the research samples. The following description is the normal data distribution plot of the three classes on the pretest.

Before the treatment, the pretest was first given to the sample using a test instrument in the multiple choice questions to determine the initial ability of the sample. Figure 1 presented the average of the initial concept of the sample.
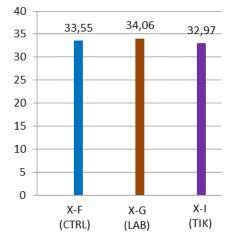

Figure 1. The average the initial ability of the sample

Based on figure 1, the average of the initial ability of the sample in the three groups is 33.55 in class X-F, 34.06 in class X-G, and 32.97 in class X-I.

The learning treatment was given to the sample after drawing because the sample was normally distributed and relatively homogeneous. The drawing results obtained that communication information technology-based learning (experiment I) carried out in class X-I, experimental laboratory-based learning (experiment II) in class X-G, and class X-F played as a control class using conventional learning.

At the end of the treatment, it continued to give posttest of multiple choice questions to test the research hypothesis, namely to find out the differences of the treatment to the students' mastery of concepts in the three research group samples.

Figure 2 is a graph of the score comparison before treatment (pretest) and after treatment (posttest) of the three groups of study samples.
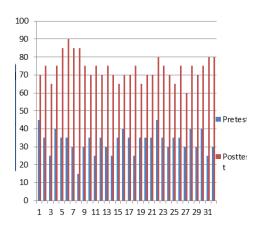
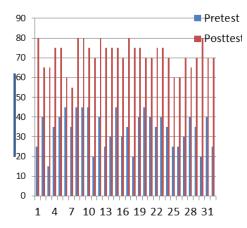**Figure 2. The comparison of the conceptual mastery before and after treatment using TIK-based learning**

Figure 3. The comparison of the conceptual mastery before and after treatment using Laboratory Experiment based-learning
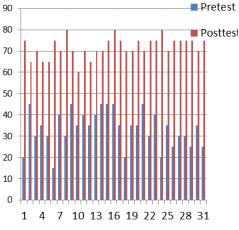

Figure 4. The comparison of the conceptual mastery before and after treatment using conventional learning

Based on Figure 2, the score of students' mastery of the physics concept before treatment using ICT-based learning was 45. And, the score of students after treatment increased to 90. This certainly indicated that there was a change/increase in students' mastery of physics concepts when they treated using ICT-based learning. According to Istiningsih (2012: p.26), learning using ICT-based learning becomes more attractive that push the students to be active because they are not only listening to lectures/descriptions of the teacher. ICT-based learning is also useful to support the inquiry, improve communication, guide the students to analyze and visualize data, encourage ideas, and build constructivist learning environments.

Eskrootchi & Oskroochi in their journal stated that in ICT-based learning, there are computer simulations that facilitate the students to understand the experiments due to it presents various kinds of graphics, animations, sounds, and voice (2010: p.273). Through ICT-based learning, learning is not only limited by time (Ravels, 2007: p.32) because experiments can be carried out quickly and more simply (Abdulwahed & Nagi, 2009: p.286).

Based on Figure 3, the score of students' mastery of the physics concepts before treated with laboratory experiment-based learning was 45. And, the score of students after treatment had the highest value of 80. This certainly showed that through laboratory experiment-based learning has changed or increased on students' mastery of the physics concepts. According to Polacek & Keeling (200: p.52), physics learning using laboratory experiment-based learning enable the students to perform various activities that explore the thoughts and understandings in daily life into learning. And, it helps the students in understanding the principles and concepts.

Based on Figure 4, the score of students' mastery of the physics concept before treatment using conventional learning was 45. And, the score of the student after treatment has the highest value of 80.

The hypothesis test performed after the research assumption test was fulfilled. The assumptions tests were homogeneity test and normality test. The homogeneity of the sample posttest tested using the Levene test with SPSS 16 for windows and show a significance analysis score of 0.938 higher than $\alpha = 0.05$. In sum, H0 accepted. Means, the variance among the three groups was homogeneous.

The normality test results on posttest using SPSS 16 for windows through Kolmogorov-Smirnov test aimed to find out whether the data of posttest results are normally distributed or not. The results showed that the significance of the three group samples is higher than $\alpha = 0.05$. The significance of experimental class I or treated using ICT-based learning is 0.160 higher than $\alpha = 0.05$. Experiment class II or treated using laboratory experiment based learning has a significance of 0.165 higher than $\alpha = 0.05$. The control class or treated using conventional learning has a significance of 0.183 higher than $\alpha = 0.05$. Means, H0 accepted or all three group samples of the populations are normally distributed. The following description described the normal posttest data plot of the three group classes.

The results of the differences in students' mastery of physics concepts between students are treated with ICT-based learning and conventional learning (control) through independent t-test samples showed that there is a significant difference in the average of students' mastery of physics concepts between students are learning by ICT based-teaching and conventional learning. And, the students' mastery of the physics concept that is treated using ICT-based learning has a higher score than students treated using conventional learning. Through ICT-based learning, students conduct inquiry activities through computer simulations. In line with Smaldino, Lowther, and Russel (2012: p.43) stated that simulations involving students into a real-life situation but in a smaller version, because ICT-based learning pushes the students to make observations and investigations without conducting direct activities which usually needs a lot of time and costs. Sutopo (201: p.11) also stated that simulations are used to examine complex and involve many interconnected quantities of an object.

The independent test results of t-test samples used to find out the differences between laboratory experiment-based learning and conventional learning (control). And, it found out that there are significant differences in the students' mastery of concepts between laboratory experiment-based learning and conventional learning. Then, it concluded that students are learning with laboratory experiment based learning have a higher mastery of physics concepts that students are learning with conventional learning. In line with Mohan (2007: p.170) that through experiments in the laboratory, students involved in activities directly to conduct scientific investigations and verification of the concepts. Also, through laboratory experiments, students participate in laboratory activities and facilitate the students to understand complex and abstract concepts or ideas. Laboratory experiments also provide opportunities for students to have
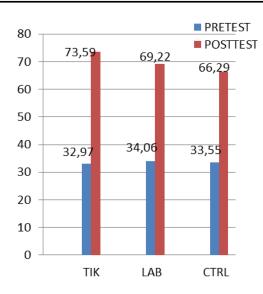
experience or perform and observe a scientific process. As a result, learning outcomes will be longer storage in memories.

The result of independent sample t-test used to determine the differences in students' mastery of physics concepts between students are treated with ICT-based learning and laboratory experiment-based learning showed that there is a significant difference in the students' mastery of physic concepts between students are treated with ICT-based learning and laboratory experiment-based learning. Students are treated with ICT -based learning has a higher score of mastery the concepts comparing than students are treated with laboratory experiment-based learning. In line with Istiningsih (2012: p.20) stated that the potential of ICT in education or learning, are: providing learning opportunities, increasing efficiency, improving the quality of learning, facilitating the skills, encouraging lifelong learning.

Through ICT-based learning, the material is packaged in a learning simulation of animations that explain the content in an interesting and lively way and combine the harmonious elements of text, image, audio, and color. In line with Cakir stated that simulations also provide unique opportunities for students because it provided repeated experiments easily in a short time and encourage the students to master the concepts of learning. Meanwhile, through laboratory experiments, students need more a long time to conduct investigations and observations toward the concept.

Based on the average score of the physics concepts of the three groups sample in Figure 5, found out that the students' mastery of physics concepts treated with ICT-based learning had the highest average value compared to other treatments. The result achieved because ICT-based learning, learning provides more fun and meaningful learning for students. Moreover, the students constructed what they obtain with the knowledge of their minds. Here, the discussions occur among either student to student or teacher. Meanwhile, the implementation of experiments in the laboratory has the disadvantage such often require various equipment or tools and material that is not always available and expensive (Sagala, 2010: p.21). The statement by Sagala was in line with the research site when the laboratory was not used as a learning source of physics and the equipment have not functioned properly. In the other hand, computer simulations do not require a lot of equipment. Moreover, observations through simulations can be done repeatedly; it provides them to have experience.

The implementation of observations on ICT-based learning might be repeated over a relatively short time because it uses computer media. Through computers, students can learn according to their abilities and speed in understanding knowledge or concepts. Whereas, observations and experiments in the laboratory require a lot of equipment and require time to assemble the equipment first before conducting research to test the theory. Computers can also create an effective learning climate and convey information with a high level of realism.

Figure 5. Comparison of the average score of students' mastery of physics concepts before and after treatment in all three groups sample

4. Conclusion

The results on average at a significance level of 0.05 showed that there are differences in the students' mastery of physics concepts between groups of students are treated with ICT-based learning and students are treated with laboratory experiment-based learning. The score of students' mastery of the physic concept of students are treated with ICT-based learning was higher than students are treated with laboratory experiment – based learning. The conclusion concluded by the analysis results that the average score of students' mastery of the concepts in dynamic electrical material using ICT-based learning was 73.59. Meanwhile, the average score of students' mastery of concepts treated using laboratory experiment-based learning was 66.29.

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