JPII 4 (1) (2015) 79-85

Jurnal Pendidikan IPA Indonesia
Indonesian Journal of Science Education

http://journal.unnes.ac.id/nju/index.php/jpii

THE EFFECTIVENESS OF PHYSICS BASED RESEARCH IN LEARNING ENGINEERING PHYSICS

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DOI: 10.15294/jpii.v4i1.3504

Accepted: 4 January 2015. Approved: 3 April 2015. Published: April 2015

ABSTRACT

This research aims to know the effect of implementation the research based learning to master properly physics concepts and students' generic ability. This research used experiment method with pretest-posttest group control design. The results of this research were the research based learning was effective to improving students' mastery of physics concepts and it was also developing the students' generic ability. The recommendation suggested to lecturer of engineering physics is implementing the research based learning.

Keywords: research based learning; generic ability

INTRODUCTION

The improvement of the quality of education is one of the national development programs. All of the educational institutions, starting from the basic level to higher level, attempt to improve the quality of education which suited with their own expertise. The society's demand in the quality of education is the main priority needed to fulfill, especially in the globalization era. The Engineering Faculty of Padang State University (UNP) as the institution which produces a vocational teacher has done several efforts to improve the quality of vocational teacher candidate. Its efforts are: (1) improving the amount and the type of laboratory equipment, (2) developing the curriculum, (3) improving the quality of the lecturers, the technicians, and the laboratory assistants. Along with the implementation of the competence basis curriculum in SMK (Vocational School), Engineering Faculty of Padang State University is evaluating its curriculum. The courses were developed based on the competency needed in the working market and industry, besides the basic competence.

The engineering Physics is one of the require courses for the students FT UNP. The Engineering Physics course in the Faculty of Electrical Engineering Program FT UNP is given in the first semester and the laboratory work of the Physics Engineering in the second semester. The physics engineering courses functions as a supported course for the competence course (MKK) of Electrical Engineering. After following the physics engineering lectures the students are expected to master the physic concept and to apply it to the competence course (MKK) of Electrical Engineering. Nevertheless, the efforts have not shown a maximize result. It is shown by the survey result on the implementation of Engineering Physics lectures in the Faculty of Electrical Engineering Education FT UNP, the results are: (1) The Engineering Physics lecturers states that the students ability in mastering the physics concept is low. It is shown by the students mean score in the Physics Engineering course which is C (55-59). (2) The lecturer of MKK Electrical Engineering says that the students' ability in applying the physics concept is low. (3) Physics enginee-

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ring course is implemented theoretically using lectures method besides question-answer session and an assignment. (4) the Physics Engineering laboratory work is done in the laboratory to test a theory (verification) by using a laboratory handout (*lab sheet*).

The low of the students' ability in mastering and implementing the physics concept is because the students are less provided with the needed abilities to master and to apply the physics concept, such as: the ability to solve the problem, the ability to think logically. The lack provisioning of those abilities can be seen from the Engineering Physics learning process which dominantly using a lectures method for example a theory explanation, an elaboration of formulas by using mathematic operational (differential and integral), and an exercise completion mathematically. Reif (1995) states that the informative learning method causing an ineffective learning because the students receive the physics knowledge nominally rather than functionally. Many lectures admit that the traditional teaching method in the physics course failed in implanting the concept understanding from the course material (Hake, 1998; McDermott and Redish, 1999). As a consequence the students are not having the needed skill in solving the problem and are not be able to applying what they have learned. This agrees with the *Physics at the Crossroads* dan *Shaping the Future* report stating the students of Physics Education University in the United States who have finished their study often are not ready to take a further education in the pure science and applied science program (Taylor et. al, 2002).

To improve the students's ability in mastering the physics concept, the courses which can supply the students with the abilities (generic ability) needed in mastering and implementing the physics concept were needed. One of the learning model which can be used is research based learning. This model is a learning process which is based on on the research approach (Wardoyo, 2013). This learning model focuses on the laboratory work using a problem solving method, inquiry, demonstration, and experiment. In this research based learning, the concept is found through the laboratory work according to the observed fact in the laboratory. This research based learning has the characteristics such as: (1) integrating the theory and the laboratory work to establish knowledge, skill, and behaviour; (2) condusive learning situation to develop creativity, motivation, and insight; (3) implement the technology. The integration of theory and laboratoy work is supported by Dugger and Johnson (1992) state that learning physics in the laboratory gives the students the oppotunity to get the theoritical knowledge and its aplication through a *hands-on* activity. The physsics learning needs to be directed to the learning which involves the students actively in forming a physic concept through the lab work.

Based on the physics learning condition which is describe above, so the efforts are needed to be done to conduct the physics learning in order to elevate the students physics concept mastery. The physics learning based research is expected to improve the students's ability in mastering the physics concept, to improve the students' skill in lab work, and to have a scientific behaviour in doing the lab work. Based on those things, then the research problem is as follows: How is the effectiveness of physics based research used in the engineering physics lectures? This research aims to describe the effectiveness oh physics based research in used in the engineering physics lectures. It is hoped that the students can master the physics concept and the physics generic ability. The result of this research is useful to improve the quality of education in Engineering Physics in the Electrical Engineering Program Padang States University.

METHOD

The method used in this researchis quasi-experimental method with the control group *pre-test-posttest* design (Creswell, 2009). The Pre-test and post-test are given to the students in the experimental group and control group by using the same exercise. The research is conducted to the 61 students of Electrical Engineering Education Program Padang States University (UNP) who follow the course of Physics Engineering 2. The Physics Engineering material presented in this research is 5 materials for direct electrical and 4 materials for magnetic field.

The steps done in conducting this research are: (1) conducting a preliminary survey, (2) arranging the research instrument, (3) conducting trials for the research instrument, (4) giving *pre-test* to the students of experimental and control group, (5) giving a treatment by applying physics learning based research to the students of experimental group, meanwhile the students of control group are giving the regular learning, (6) evaluating the students generic ability in the physics learning based research when the teaching-learning process is occurred for every subject, (7) giving *post-test* to the students of experimental and control group, (8) analyzing and interpreting the

data.

The instruments used in this research are; the observation sheet, the assessment sheet on generic ability, and test in mastering the physic concept. The observation sheet is used as guidelines to do the preliminary research. The assessment sheet is used to assess the students' ability in analyzing the problem, constructing the solution through the lab work, examining the solution, presenting the finding, and presenting the lab work finding. There are two documents of the test on mastering the physics concept used in this research; they are the exercise for the direct electrical material and the exercise for the magnetic field material. Those two documents is an essay test which mainly promotes the questions of physics concept rather than the mathematic calculation using many physics formulas. The exercises were compiled by the researcher with the help of expert judgment to know the test validity. The construct validity and the reability test were obtained in the research instrument trial. By means of trial process, the exercise to master the physics concept for the direct electrical material is 16 items and for the magnetic field material id 12 item.

The physics concept mastery data are analyzed quantitatively to figure out the physics concept mastery in the learning based research. The improvements of the students' concept mastery are analyzed by calculating the *gain* mean score which being normalized by the *pre-test* and *post-test* score. The different mean score of the students' physics concept mastery in the experimental and control group is analyzed by using the t-test. The data of the students' skill in: analyzing the problem, constructing the solution through the lab work, examining the solution, presenting the finding, and presenting the lab work finding were analyzed by calculating the mean score in every skill and compared it to the categorized score.

RESULT AND DISCUSSION

Analysis was done on the *pre-test* and *post-test* for the direct electrical material, magnetic field, and the combination of these materials. The data analysis aims to investigate the effectiveness of the physics learning based research used in the engineering physics lectures. The effectiveness of the physics learning based research is reviewed from: (1) the improvement of the physics concept of the student in the experimental group, (2) the discrepancy of the mean score of the physics concept between the experimental group and control group, and (3) the students' generic ability of the experimental group in the physics engineering lectures. Then, each aspect was analyzed to know the effectiveness of the learning model implementation.

The improvement of the students' physics concept mastery can be known by calculating the *gain* mean score which being normalized (NG) from the *pre-test* and *post-test.* After the tests are being analyzed, the NG mean score is obtained. The NG score in the concept mastery in the experimental group is 0,31 and the standard deviation is 0,31. Based on the normalized *gain* score, the improvement of concept mastery is categorized Fair. If it is seen from the discussed engineering physics material, the NG mean score is 0,36 with the standard deviation 0,11 for the direct electrical and the NG mean score 0,27 with the standard deviation 0,15 is for the magnetic field material. The improvement of the students' concept mastery in the direct electrical material is categorized Fair and in the magnetic field is classified to Low category.

The students' concept mastery improvement in the experimental group is visualized by the graphs in the Figure 1.

Before analyzing the data to find out the difference of the mean score in mastering the physics concept both in the experimental and control group, by means of the t-test, the normality data distribution test and the homogenous data test were previously conducted. These tests were a requirement data analysis test to determine the used t-test formula. The result of the normality data distribution test showed the *pre-test* and *post-test* data in the students' concept mastery in the experimental and control group is at the normal distribution in the significance level $\alpha = 0,05$ (Table 2).

The result of the homogenous data shows that the *pre-test* data the students' physics concept mastery both in the experimental group and the control group are homogenous ($\alpha = 0,05$), the

Table 1. The Improvement of Physics Concept Mastery

Material	*Pre-test* Mean Score	*Post-test* Mean Score	NG Mean Score	Category
Direct electrical	52,82	69,66	36 (%)	Fair
Magnetic field	48,56	62,07	27 (%)	Low
Combination	50,69	65,86	31 (%)	Fair

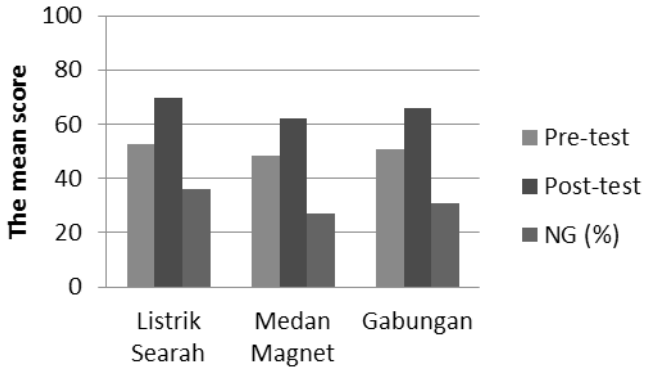

Figure 1. The students' concept mastery improvement in the experimental group

Table 2. The result of the normality data distribution test showed the *pre-test* and *post-test*

The Test Group	X^2_{hitung}	X^2_{tabel}	dk	Category
Pre-test experimental group	1,724	38,885	26	Normal
Post-test experimental group	2,379	37,652	25	Normal
Pre-test control group	1,750	42,557	29	Normal
Post-test control group	2,438	41,337	28	Normal

Table 3. The Result the test of Homogenous Data in the Experimental and Control Group

The Test Group	F_{hitung}	F_{tabel}	Dk	Category
Pre-test	1,42	1,84	31,28	Homogen
Post-test	1,60	1,84	31,28	Homogen

post-test data show the sama result as the *pre-test.* (Table 3).

Based on the normality data distribution test and the homogenous data test in mastering the physics concept to the experimental and control group of students, so it is defined that can use the t-test (with the formula for the normal and homogenous data). After conducting the contrast test of the mean score in students' mastering the physics concept, the result shows the mean score *pre-test* in mastering the physics concept in the students of experimental and control group is not different considerably (α = 0,05). It can be said that the students' mastery in the physics concept before the engineering physics course is started,is the same at the both classes. The contrast test of the *post-test* mean score in the concept mastery shows that the *post-test* mean score in mastering the physics concept in the experimental and control groups is different significantly (α = 0,05). After using the learning based research in both class, the student' concept mastery is different. The mean score in mastering the physics concept in the experimental group is higher than control group. The contrast test of the mean score in the students' physics concept mastery (NG) shows that the NG mean score for the experimental group and the control group is different significantly (α = 0,05). Therefore, there is a difference level in mastering the physic concept after taking the engineering physic. The mean score in mastering the physics concept in the experimental group is higher than control group. The result of the contrast test of the mean score in mastering the physics concept for the experimental group and control group to the group of test *pre-test*, *post-test*, and NG is presented in the Table 4.

The visualization of the difference of the *pre-test* and *post-test* mean score in mastering the physics concept is presented in Figure 2.

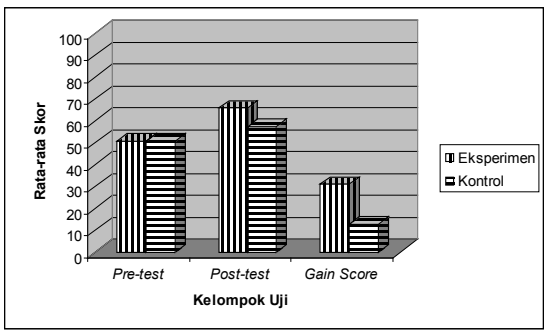

Figure 2. The Discrapency of the Students' Physics Concept Mastery

Table 4. The Result of The Contrast Test of The Mean Score in Mastering The Physics Concept for The Experimental and Control Group

The Group of Test	Treatment group	Mean Score	Deviation Standard	Value of t_{hitung}	explanation
Pre-test	Exp	50,69	9,07	0,014	insignificant
	control	50,73	10,80		
Post-test	Exp	65,86	8,61	3,306	Significant
	control	57,49	10,89		
NG	Eksp	0,31	0,10	5,590	Significant
	Kontrol	0,13	0,14		

Explanation: t_{tabel} = 2,000

Table 5. The Students' Generic Ability in Engineering Physics learning

No.	Ability	Mean Score	Deviation Standard
1	Analyzing the problem	63,17	11,94
2	Constructing a solution through a lab work	82,28	4,91
3	Examining the solution	69,69	10,42
4	Presenting the finding	78,83	8,35
5	Presenting the lab work finding	68,38	9,71

In physics based research evaluation is needed in learning process. The evaluation learning process aims to know the students's ability in learning Engineering Physics. The abilities, in this case, is the physics generic ability including: (1) analyzing the problem, (2) constructing a solution through a lab work, (3) examining the solution, (4) presenting the finding, (5) presenting the lab work finding. The ability in analyzing the problem is the ability in discussing the concepts needing to solve the problem. The ability in constructing a solution is the ability to do the lab work. The ability in examining the solutionis the students' ability in examining whether the found concept in the lab work can support the problem solution or not and whether the answer or solution of the problem is found. The ability in presenting the finding is the ability in arranging and writing the lab report including: presenting the data, analyzing the data, and summarizing. The ability in presenting the lab work finding is the ability in presenting and discussing the lab work finding with other groups. The mean score of the students' generic ability in Engineering Physics learning is presented in the Table 5.

According to the Table 5 dan assessment category in the guidebook Padang States University it can be concluded that the students' ability in: (1) analyzing the problem is categorized Fair, (2) constructing the solution through the lab work is categorized Good, (3) examining the solution is categorized Good, (4) presenting the finding is categorized Good, and (5) presenting the lab work finding is categorized Good. The mean score in the students' ability in the learning implementation in Table 5 is visualized in the graph Figure 3.

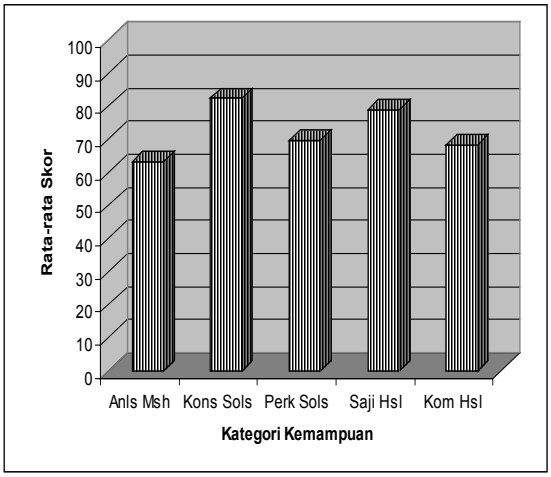

Figure 3. The Graph of the Students' Ability in Learning Implementation

The improvement of the students' physics concept mastery in experimental group is including in Fair category. Although the physics concept mastering for the experimental group is categorized into Good (the mean score *post-test* 65, 86). If it is reviewed from the mean score of the students' concept mastery in the experimental group for the material tested in the engineering physics, there is a different of the mean score in the direct electical material nad the magnetic

field material. The students' mastery for the direct electrical material of the students in the experimental group is higher than the magnetic field material, both in the *pre-test* and *post-test.* It shows that the magnetic field material is more difficult to understand than the direct electrical material. The possible factor which causes the students' difficulty is many concepts or theories in the magnetic field is difficult to prove because of the lack of laboratory equipment. For example, in discussing the sub material in electric vehicle principle, the students can only observe the round rotor on the electric vehicle. The students cannot measure the rotor speed because of the lack of a device to measure round speed in laboratory.

Referring to the data analysis result and comparing the students' generic ability mean score in learning based research physicswith the score category, so it obtained that the students' ability in constructing the solution is categorized good, examining the solution, presenting and communicating the lab work finding are Good. It agrees with the Kurnianto, Dwijananti, and Khumaedi (2010) research finding which concluded the physics learning along with its lab work activity can improve the ability in interpreting the physics concept. From several generic abilities which can be expressed in the based research physics, in fact the students' ability in analyzing the problem includes in Fair category. It probably because the students have not the preliminary knowledge relates to the topic which is discussed. The ability to analyzing the problem, to construc the solution, and to examine the solution is part of problem solving. The students' conceept mastey in physics can be improved by doing the problem solving activity as a group (Bormann, 2012).

The improvement of students' concept mastery in learning physics and the students' generic ability are obtained in the physics based research supported by McDermott (1975) who says that the students must be able to do the laboratory work besides to master the esential concept. The students' ability in performing the laboratory work, solving the problem, and presenting the lab work finding have completed the three ABET criteria (Lattuca, Terenzini and Volkwein, 2006). The ability in constructing solution is the ability in performing the inquiry laboratory work excellently. This research finding is supported by the research of Coox and Junkin (2002) and Jongdee (2009) who find that the inquiry laboratory work can increase the students' performance in doing the lab work. Weaver, Russell & Wink (2008) and Deters (2005) in their research find that the inquiry lab work activity can increse the students to think logically, to solve the problem, and to give an good experience in a lab work activity.

CONCLUSION

The research finding shows that the implentation of basic research physics is effective to increase the students's concept physics mastery dan the generic ability.the effectiveness of this model learning is reviewed from: (1) the improvement of the students' physics concept mastery in the experimental group, (2) the difference of the mean score of the students' physics concept mastery both in the experimental group and the control group, and (3) the students' generic ability in the experimental group in the physics based research.

This research finds that the improvement of the students' physics concept in the experimental group is categorized Fair. the improvement of the students' physics concept in the control group is categorized Low. There is a significant discrepancy between the meaan score of the students' mastery physics concept in the experimental group and the control group. The mean score os the students' mastery physics concept in the experimental group higher than the control group. The mean score in the students' mastery concept in experimental group is good. The students' generic ability in the physics based research in the experimental group is categorized good. The abilities are analyzing the problem, constructing the solution, examining the solution, presenting the finding, and presenting the lab work finding.

The physics learning using the physics based research can improve the mastery of the physics concept and the generic ability needed by the students in implementing the physics concept. Therefore, the engineering physics lecturers is hoped to use this learning model to the students of Electrical Engineering Education Program.

Considering it consumes much time to discuss one topic, so the Engineering Physics which consists of the meeting, the structural assignment, and the individual assignment must be done by the students very well. The lecturers of the engineering physics is expected to facilitate and to motivate their students to do meeting activities, structural assignment, and individual assignment. To increase the students' motivation in the engineeering physics lectures, the lecturers is expected to return the assignments, the lab work report, and the exam result to the students.

The model of physics based research was conducted in the llaboratory because the learning stages involve the lab work so it is needed the lab

equipments which support the learning process. The Head of Laboratory is expected to try to find the solution of inadequate lab equipments, for example make a cooperation with other lab from other faculties or universities.

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