Problem project learning model to improve physics student's product performance and process performance

Dwikoranto[1, a], Munasir[1], R Setiani[2], Suyitno[3], S Tresnaningsih[4], and Pramonoadi[4]

[1]Department of Physics, Faculty of Science and Mathematics, Universitas Negeri Surabaya, Surabaya 60231, Indonesia
[2]STKIP PGRI Tulungagung, Indonesia
[3]Universitas Lambung Mangkurat Banjarmasin
[4]Universitas Terbuka Indonesia

[a]dwikoranto@unesa.ac.id

Abstract. The aim of this research is to describe a practical and effective Problem Project Learning (PPL) model to improve students' product and process performance. Research subjects was physics student of Unesa. Trial using one-group pre-test and post-test design. Data were collected by validation method, observation, test, documentation, interview, and questionnaire. Data were analysed using descriptive quantitative and qualitative. The results of the research show: 1) The model is categorized practically in terms of: (a) the implementation of the PPL model with good criteria on model implementation trials; (b) active students in physics learning using the PPL model; 2) The model in the effective category are reviewed from: (a) Improving students' process performance skills with moderate criteria on limited trials and high criteria in broad trials, (b) Improvement of student product performance by medium criterion in limited trials and extensive trials. The PPL model developed was practical and effective for improving process and product performance.

1. Introduction

Problem solving is a basic part of the physics course and the problem-solving skills themselves are very useful skills because they contribute to the understanding of physics [1]. Competency Standards of Physics Education graduates include: (1) mastery of material, structure, competence, concept of physics and its application in technology, (2) application of principles, concepts and laws of physics in the form of prototypes of science and technology products relevant to the needs of society, utilizing information and communication technology for the benefit of strengthening and dissemination of scientific physics products [2]. Students of physics who later carry out learning in schools are expected to invite students to apply, process every element of the concept learned to make generalizations, and invite students to evaluate the concepts and principles that have been studied. Meanwhile, aspects of skills and attitudes should not be overlooked.

Teachers who have not been able to separate the studied physics product aspect, in the way that physics is taught to student aspects of the process require good learning [3]. Physics students should be given the opportunity to study the nature of the subject matter, to understand not only what they know from the product aspect but on how the facts from which knowledge is derived rationally from the process aspect. Five important principles set by the National Society of Colleges of Teachers of

Education as a guide when studying a skill: (1) professionally serving laboratory facilities for teacher observation and participation (2) conducting research and experimentation on the growth and development of children in using learning materials and teaching procedures, (3) tests and demonstrations that take into account the exercises in schools, (4) enrichment programs for graduates, (5) leadership training for teachers through in-service training [4].

Preliminary study on the physics lab lectures showed that there were some problems faced by students such as: (1) the defense of basic concepts and basic skills of students on laboratory materials, (2) the skills to identify laboratory problems in physics learning precisely and how the solution techniques are. (3) the design of the tools made by the students is largely unable to meet the standard of science aids, (4) the design of the tools made by the students cannot be operationalized for practical activities complete with the guidance [5,6].

Regarding the problem-solving ability of Unesa physics students still need to be improved and related to the physics tools created by the students is still relatively at the stage of exploring the idea. Students have not made science product that can be operated to improve the quality of learning and research in the field of physics. The tools that are made largely just to fulfill the task of the course, have not been based on the problems identified and based on need [5]. Relation product performance suggest that the creative product produced is still limited to creative and imaginative ideas, so it is necessary to improve the quality and usefulness of creative products in real life. Creative products on practicum tools are still lecturers who make and provide yet to be done by students [7].

In line with Chang's [8] opinion on problem solving ability, creating productively becomes a problem for students in the physics department in solving physics problems. A learning model is needed that further trains students to be skilled in solving physics problems and producing products. Problem Based Learning (PBL) was used successfully as an instructional strategy in college [9]. Suggest that some principles of effective PBL are used in learning. Designed PBL research on force and motion material and obtained no significant difference in gain between knowledge of experimental class and control class, but there was a change in attitudes toward science [4]. PBL is chosen in science teaching, because through science lesson projects especially physics becomes more interesting [10]. The focus of the PBL is on the key concepts and principles of a discipline, engaging students in problem-solving activities and other meaningful tasks, giving students the opportunity to work autonomously constructing their own learning, and peak producing student work products [11].

Korkmaz in Rais, observed that there are significant differences in the creative thinking ability of groups of learners with traditional learning approaches with students learning with project-based learning models. Excellence model project-based learning in the improvement of thinking ability was revealed by Rais [11] in his research that the project-based learning model can improve students' ability in thinking habituation, in this case thinking habituation is about creative thinking. Lessons learned in project-based learning models can foster students' efforts to build a complex and rich memory representation of experience, indicating a strong level of linkage between semantic, episodic, and action knowledge [12]. Students taking action to produce products in project-based learning also apply basic competencies to aspects of scientific performance or aspects of the science process skills, such as planning and design, use of equipment, implementation, observation and recording, interpretation and responsibility. So, this project-based learning model has tremendous potential to make the learning experience more interesting and meaningful.

In the Physics Laboratory course there is a Competency Standard 3: Applying principles, concepts, and laws of physics in the form of prototype science and technology products that are relevant to the needs of society. Sub competence 3.1: Produce prototype of science and technology products for strengthening and development of physics education. The prototype needs to get attention in the lecture. Competency graduation standard 7: Develop and manage laboratories for school physics teaching. Sub competence 7.3 Designing physics experiments for learning or research needs also needs to be improved. Designing the product and complete with operational practicum guidelines for practicum titles that do not yet exist should be made by physics teacher candidates [2, 5].

The practice manual which is the output of the process performance contains the Skills Process of Science (SPS) with components: formulating the problem, formulating the hypothesis, identifying variables, defining variables, designing data tables, designing procedures, analyzing data, drawing conclusions, still low since 1982 until now [7]. There is an indication that if there is no treatment or intervention on SPS of prospective teachers, SPS tends to be stagnant. Implementation of Creative Responsibility Based Learning model from Suyitno, able to increase average of correct answer proportion from 0.32 to 0.72 in physics education program [7].

Research on the Skill of Science Process of the students of Department of Biology, Physics, and Chemistry FKIE IKIP Bandung, Surabaya, Yogyakarta, and Ujung Pandang conducted by Nur in Sudibyo [13] obtained the average result of correct answer proportion of 0.46. The student has not been able to properly plan the experiment. The correct answer proportion of 0.03 means that out of 100 students only three people can plan the experiment correctly. They are unfamiliar with the task of identifying independent variables, response variables and control variables.

Skills Process of Science Survey in Faculty of Science and Mathematics Unesa to S1 students of Biology, Physics and Chemistry force of 2014 has not reached 60. Not competent in planning and executing experiment. There is an indication they are carrying out experiments with procedures that have not been correct. This indication is reinforced by certain aspects of PPP scores such as observation, manipulation of variables, and control of variables below 50. Even control of the four forces of the force is below 40 [13]. The low Skills Process of Science score above is confirmed by an international study that Indonesia is one level below Brazil and one level above Tunisia. Indonesia is ranked 39th from 40 countries in the world [7].

Some of the titles of practicum activities for the availability of limited equipment are not even available. Prospective physics teachers who meet good quality standards must master laboratory equipment in support of learning activities in the classroom. If this type of practicum does not exist and is required, the student designs it and produces the work for the physics lab course subjects that are programmed. To encourage prospective teachers to produce either individual or group contextual work, it is advisable to use project-based learning in conjunction with Project-Based Assessment Standards [14]. Project Based Learning (PjBL) uses the project as a medium. Students undertake exploration, assessment, interpretation, synthesis, and information to produce various forms of learning outcomes. Project Based Learning, which uses the problem as a first step in collecting and integrating new knowledge based on its experience in real-life activities, is designed to be used on complex issues that students need to investigate and understand. Through PjBL, the inquiry process begins with raising a guiding question and guiding students in a collaborative project that integrates the various subjects in the curriculum. At the time the question is answered, it can directly see the various main elements as well as the various principles in a problem being studied. PjBL is an in-depth investigation of a real-world topic, it will be valuable to the attention and effort of the students. Given that each student has a different learning style, project-based learning provides an opportunity for students to explore material content using various means that are meaningful to themselves, and conduct collaborative experiments.

In relation to the above problems, it is necessary to develop a model of learning that is integrated between problem based learning (PBL) process oriented with project based learning (PjBL) which is product oriented in the subject of Physics Laboratory which is expected to be able to improve the performance of physics teacher candidate. The developed model is called Problem Project Learning abbreviated as PPL. Problems to be answered through this research is how the practicality and effectiveness of Problem Project Learning Model (PPL) developed to improve process performance and product performance of physics teacher candidate.

The learning model is a broad and thorough teaching approach, has a coherent theoretical basis or the rationale of the learning objectives to be achieved, the teaching behavior, and the learning environment necessary to achieve the learning objectives [15]. Model Problem Project Learning (PPL) is a broad and comprehensive teaching approach with phases: (1) Essential and problem-oriented questions, (2) Project Planning Design and Preparing Activity Schedule, (3) Student Monitoring and Project Progress, (4)) Develop and Present Artifacts and Showcase, (5) Analyze and Evaluate problem-solving process as well as Evaluate experiences and learning outcomes. Model PPL to improve process performance and product performance of physics teacher candidate. Process and product performance are emphasized on science problem solving, science experiment, and product design [16].

The practicality of PPL model includes expected and actual aspect. Expected means the intervention is expected to be applied in a setting that has been designed and developed. Actual means can be applied in settings that have been designed and developed. The effectiveness of PPL model includes expected and actual aspects. Expected means the use of the intervention is expected to give the desired result. Actual means the use of interventions gives results as desired [17].

2. Method

Preliminary research, prototyping stage, assessment phase [18]. Basically, the stage is done to describe the validity, practicality, and effectiveness of the developed PPL Model. Assessment phase is a development process to get a valid final prototype, practical and effective. Trial II using Prototype III is done in the same class.

O_1	x	**O_2**

Figure 1 Scheme one group pre-test and post-test design.

Where:
O1 = pre-test done before the implementation of the PPL model
O2 = post-test is done after execution of PPL model with prototype III
X = treatment using PPL model with prototype III

The practical variables of the PPL model include the implementation of the PPL model, student activities, and implementation constraints of the PPL model. The effectiveness variables of PPL model include process performance, product performance.

Subjects of research on limited trials are Unesa Physics Education Program students who programmed on even semester from academic year of 2015/2016. The subjects of the research on extensive trials were planned on Unesa physics education program students who programmed on odd semester and even semester from academic year of 2016/2017 by using learning devices on revised limited trials. Instruments developed to collect the following data: 1) The assessment sheet Process Performance (Skills Process Science); 2) The assessment sheet Product Performance.

Data collection techniques used in this study as follows: observation, test, documentation, interviews; and, questionnaires. Data analysis techniques used in this study vary depending on the research objectives to be achieved. Generally, analyzed descriptively, the N-gain test is used to analyze the improvement of process performance and product performance.

3. Results and Discussion

3.1. Practicality of model PPL

The implementation of Lecture Unit (LU) model PPL is the achievement of the model phases during the learning process. Some of the preparations made before the learning process, among others: Discussion with model lecturers and observers to find an understanding of their respective roles in the study. Modelling experimental activities in worksheet using tools and materials. Modelling of learning activities using LU tools that have been provided to provide direct experience to the model lecturer who will be a lecturer and observer who will observe the learning process, and know the practicality of the model and the LU device developed. The modelling was done on the students of other physics class physics class of 2015/2016 that program physics lab course, and the researcher acted as lecturer.

Learning begins with a pre-test, students do a process skill test and product performance test, then fill in a questionnaire. Process skills include formulating problems, formulating hypotheses, identifying variables, making operational definitions of variables, designing observational data tables, designing experimental procedures, analyzing data, and drawing conclusions. Observers observe the student process and product performance, LU implementation, and learning implementation constraints. Learning ends with post-test.

Assessment of LU implementation by 2 observers using the LU-model PPL Performance Instrument results show that the implementation of the phases of the PPL model at meetings 1 to 3 has minimal criteria implemented, whereas all phases at 4 to 6 meetings in the criteria are well established. Model lecturers can carry out the model phases in the learning process well. The reliability coefficient of the model phases at each meeting above 75%, means the observation results of the implementation of each LU in the criteria reliable. Constraints to the implementation of learning that the implementation of learning with PPL model at the beginning of the meeting experienced some technical and non-technical obstacles that can be overcome at the end of the meeting.

3.2. The effectiveness of the PPL model product performance

Product performance measures the ability to improve the function of a laboratory equipment product made by students technically. The product performance components measured are: experimental and product design. Students are expected to improve the function of a laboratory equipment product technically smoothly, flexibly, and original in the form of operational manual instructions and set of tools practicum in accordance with the instruction practicum made. A summary of the results of product performance test value analysis is summarized in Table 1 below.

Table 1. Results of product performance test on limited trial test.

Criterion of Assessment		Pre-test			Post-test		
		Σ student	%	$\bar{x}$	Σ student	%	$\bar{x}$
Fluently	Very fluently	0	0.00	36.66	24	80.00	92.20
	Fluently	7	23.33		5	16.67	
	Less fluently	20	66.66		1	3.33	
	Not fluently	3	9.60		0	0.00	
Flexibility	Very flexible	2	6.66	43.33	18	60.00	86.66
	Flexible	8	27.00		11	36.67	
	Less flexible	16	53.33		1	3.33	
	Not flexible	4	13.33		0	0.00	
Originality	Very original	12	40.00	71.11	26	86.66	94.40
	Original	14	46.66		3	10.00	
	Less original	0	0.00		1	3.33	
	Not original	4	13.30		0	0.00	

The N-Gain values and the sensitivity of the items on product performance in the limited trial can be seen in Table 2 below.

Table 2. N-Gain value and sensitivity.

No	Aspect of Assessment	N-Gain		Sensitivity	
		Coefficient	Meaning	Coefficient	Meaning
1	Fluently	0.80	High	0.42	Sensitive
2	Flexibility	0.76	High	0.41	Sensitive
3	Originality	0,80	High	0,23	Not sensitive

Improved product performance before and after the learning process on all aspects of fluency, flexibility, and originality in high criteria. The items used are generally good and sensitive to the learning process, especially fluency and flexibility, but less sensitive to originality. Most students have the initial ability to improve a product technically as demonstrated by the pre-test value of product performance on the original aspect of 70.00.

3.3. Experiment designing

Experiment designing measures the ability to design an experimental instruction creatively. Examples of test items used are, "Given 20 minutes is provided 4 pieces of identical and different battery brands, connecting cable, 2 pieces of lights, 1 switch. Write an experimental plan (including formulating hypotheses, identifying variable and variable operational definitions, designing data tables and experimental procedures) to find the relationship between the current strength and the battery voltage. The summary of the test result analysis is shown in Table 3 below.

Table 3. Experiment designing test value test result.

Criterion of Assessment		Pre-test			Post-test		
		Σ student	%	x̄	Σ student	%	x̄
Fluently	Very Fluently	0	0,00	18.89	26	86.67	88.33
	Fluently	4	13.33		3	10.00	
	Less Fluently	6	20.00		0	0.00	
	Not Fluently	20	66.67		1	3.33	
Flexibility	Very flexible	0	0.00	21.11	22	73.33	87.78
	Flexible	3	10.00		5	16.67	
	Less flexible	13	43.33		3	10.00	
	Not flexible	14	46.67		0	0.00	
Originality	Very original	2	6.67	6.67	8	26.67	54.44
	Original	0	0.00		6	20.00	
	Less original	0	0.00		13	43.33	
	Not original	28	93.33		3	10.00	
experiment designing	Very creative	0	0.00	15.56	20	66.67	76.85
	Creative	1	3.33		6	20.00	
	Less creative	5	16.67		3	10.00	
	Not creative	24	80.00		1	3.33	

The results show that the application of the PPL model can increase the average test experiment designing value in all aspects of fluency, flexibility, and originality. The application of the PPL model can increase the number of students who meet the criteria of fluency, flexibility, and originality. Initially, students who have the initial ability in designing an experiment on criteria less creative as much as 29 students. They have difficulty in designing an experiment that meets the criteria of fluency, flexibility, or originality. The application of the PPL model can increase the number of students who meet the creative criteria in completing the experiment designing test from 1 student to 26 students. Most students can design an experiment that includes formulating hypotheses, identifying variables, making operational definitions of variables, designing observational data tables, and designing experimental procedures smoothly and flexibly but less original.

The value of n-gain and the sensitivity of the experiment designing items on the limited trial can be seen in Table 4 below.

Table 4. N-Gain value and sensitivity of experiment designing test item.

Number	Aspect of Assessment	N-Gain		Sensitivity	
		Coefficient	Meaning	Coefficient	Meaning
1	Fluently	0.82	High	0.70	Sensitive
2	Flexibility	0.83	High	0.64	Sensitive
3	Originality	0.50	Rather high	0.46	Sensitive
Experiment designing		0.72	High	0.61	Sensitive

The results show that experiment designing increases before and after the learning process on the aspect of originality in the medium criterion and the aspect of smoothness and flexibility in high criteria. Items used are good and sensitive to the learning process in all aspects of fluency, flexibility, and originality.

3.4. Product design

Product design measures the ability to design a product creatively. Product design is prepared in accordance with experiment design. Students are expected to create a logical design and show smoothness and flexibility in explaining the names and functions of the parts in the design. The results of product design test value analysis are shown in Table 5 below.

Table 5. Results of product design test value test on limited trial.

Criterion of Assessment		Pre-test			Post-test		
		Σ student	%	$\bar{x}$	Σ student	%	$\bar{x}$
Fluently	Very fluently	3	10.00	56.67	22	73.33	91.11
	Fluently	18	60.00		8	26.67	
	Less fluently	6	20.00		0	0.00	
	Not fluently	3	10.00		0	0.00	
Flexibility	Very flexible	4	13.33	56.67	11	36.67	93.33
	Flexible	16	53.33		9	30.00	
	Less flexible	7	23.33		0	0.00	
	Not flexible	3	10.00		0	0.00	
Originality	Very original	2	6.67	21.11	4	13.33	54.44
	Original	2	6.67		11	36.67	
	Less original	9	30.00		15	50.00	
	Not original	17	56.67		0	0.00	
Product design	Very creative	4	13.33	44.81	23	76.67	79.63
	Creative	9	30.00		7	23.33	
	Less creative	8	26.67		0	0.00	
	Not creative	9	30.00		0	0.00	

The results of applying PPL model can increase the average of product design test value in all aspects of smoothness, flexibility, and originality. The application of the PPL model can increase the number of students who meet the criteria of fluency, flexibility, and originality. as many as 17 students have early skills in designing a science product in less creative criteria. They have difficulty showing smoothness, flexibility, and originality in providing answers. Application of PPL model can increase the number of students who meet the creative criteria in completing product design test from 13 students to 30 students. Most students can design a science product smoothly and flexibly, but 22 students show little novelty.

The N-gain value and the sensitivity of the item on the product design in the limited trial can be seen in Table 6 below.

Table 6. N-Gain value and sensitivity of product design test item.

Number	Assessment	N-Gain		Sensitivity	
		Coefficient	Meaning	Coefficient	Meaning
1	Fluently	0.79	High	0.40	Sensitive
2	Flexibility	0.85	High	0.40	Sensitive
3	Originality	0.42	Medium	0.19	Not sensitive
Product design		0.63	Medium	0.33	Sensitive

The results show the improvement of product design before and after following the learning process on the aspect of originality in medium criteria and the smoothness and flexibility aspects in the high criteria. The items used are generally good and sensitive to the learning process especially in the aspect of fluency and flexibility, but less sensitive to aspects of originality. Most students still have difficulty in designing a logical picture of the equipment.

3.5. Performance process

Process performance measures students' Skills Process Skills abilities. Indicators of process performance in accordance with Indicators of science process skills taken are: formulating problems, formulating hypotheses, identifying variables, defining operational variables, designing data tables, designing experimental procedures, analyzing data, drawing conclusions. The results of the analysis of test performance value of the process is presented in Table 7 below.

Table 7. Results of analysis of process performance test on limited trial.

Indicator	Meaning	Pre-test			Post-test		
		Σ student	Completeness Indicator	$\bar{x}$	Σ student	Completeness Indicator	$\bar{x}$
Formulate the problem	Mastery	2	6.67	49.17	29	96.67	96.67
	Not mastery	28			1		
Formulate the hypothesis	Mastery	6	20.00	34.17	29	96.67	98.33
	Not mastery	24			1		
Identify variable	Mastery	0	0.00	12.50	26	86.67	90.00
	Not mastery	30			4		
The definition of operational variables	Mastery	7	23.33	44.17	26	86.67	79.17
	Not mastery	23			4		
Designing data tables	Mastery	16	53.33	62.50	25	83.33	74.17
	Not mastery	14			5		
Designing an experimental procedure	Mastery	9	30.00	26.67	28	93.33	80.83
	Not mastery	21			2		
Analytical data	Mastery	11	36.67	50.83	27	90.00	89.17
	Not mastery	19			3		
Draw a Conclusion	Mastery	6	20.00	23.33	13	43.33	70.00
	Not mastery	24			17		

The results show that the completeness of the process skill indicators before following the learning process is generally still low. Most students have difficulty applying process skills in solving science problems. The application of the PPL model can improve the completeness of all science process skill indicators, although some students still struggle to draw conclusions appropriately. The value of n-gain and the sensitivity of the grains on process skill in the limited trial can be seen in Table 8 below.

Table 8. N-Gain value and sensitivity of process performance test items.

Number	Indicator	N-Gain		Sensitivity	
		Coefficient	Meaning	Coefficient	Meaning
1	Formulate the problem	0.93	High	0.48	Sensitive
2	Formulate the hypothesis	0.97	High	0.64	Sensitive
3	Identify variable	0.89	High	0.67	Sensitive
4	The definition of operational variables	0.63	Medium	0.35	Sensitive
5	Designing data tables	0.31	Medium	0.12	Not sensitive
6	Designing an experimental procedure	0.74	High	0.54	Sensitive
7	Analytical data	0.78	High	0.38	Sensitive
8	Draw a conclusion	0.61	Medium	0.45	Sensitive

The results show that improving the science process skills in terms of formulating problems, formulating hypotheses, identifying variables, designing experimental procedures, and analyzing data in high criteria, as well as making operational definitions of variables, designing tables of observational data, and drawing conclusions in medium criteria. Grain of process skill used in general good and sensitive to learning process, except designing table of observation data not yet sensitive to learning process.

4. Conclusion and Suggestion

This development research produces research products in the form of Problem Project Learning model and its supporting tools and shows that:

1. The developed model is categorized practically in terms of: (a) the implementation of the PPL model with good criteria on model implementation trials; (b) Active students in physics learning using the PPL model;
2. The models in the effective category are reviewed from: (a) Improving the students' process performance skills with moderate criteria on a limited trial, (b) Improving the performance of the student products with the criteria being on a limited trial.

The implication of this research is that Model Problem Project Learning can be used as an alternative to improve product performance and process performance of prospective physics teacher students in universities that have physics lab course or similar character. Suggestions for research on extensive trials should experiment designing and product design on improved aspect of originality.

References

[1] Giancoli D C 2011 *Physics Principles with Aplication* (New Jersey: Prentice Hall International.)
[2] Universitas Negeri Surabaya (Unesa) 2014 *Buku Pedoman Unesa 2014-2015* (Surabaya: Unesa Press.)
[3] McDermott L C, Shaffer P S and Constantinou C P 2000 *Phys Educ.* **35 (6)** 411
[4] Akınoğlu O and Tandoğan R Ö 2007 *J. Math. Sci. T.* **3 (1)** 71
[5] Anifah L, Nurkholis dan Dwikoranto 2015 Pengembangan Desain Pembelajaran untuk Meningkatkan Kinerja Calon Guru Fisika *Laporan Hibah IDB PUPT* (Surabaya: Unesa)
[6] Direktorat Pembinaan Sekolah Menengah Atas Direktorat Jenderal Pendidikan Menengah Kementerian Pendidikan dan Kebudayaan 2011 Pedoman *Pembuatan Alat Peraga Fisika*

untuk SMA (Jakarta: Direktorat Pembinaan Sekolah Menengah Atas Direktorat Jenderal Pendidikan Menengah Kementerian Pendidikan dan Kebudayaan)

[7] Suyitno 2017 Model Responsibility and Scientific Creativity Based Learning (RSCBL) untuk Meningkatkan Kreativitas Ilmiah dan Tanggung Jawab Mahasiswa *Disertasi* (Surabaya: Pasca Sarjana Unesa)

[8] Chang C Y 2008 *Res. Sci. Educ*. **40 (2)** 103

[9] Savery J R. and Duffy T M 2001 Problem Based Learning: An Instructional Model and its Constructivist Framework *Technical report* (Bloomington, IN: Indiana University)

[10] Rais M and Lamada M S 2010 Pengembangan model Project Based Learning: Suatu Upaya Meningkatkan kecakapan Akademik Mahasiswa Jurusan Teknik Mesin UNM *Laporan Penelitian Tahun II DP2M DIKTI-LEMLIT UNM* (Makasar: Universitas Negeri Makasar)

[11] Kamdi W 2008 Project-Based Learning: Pendekatan Pembelajaran Inovatif *Makalah disampaikan dalam Pelatihan Penyusunan Bahan Ajar Guru SMP Dan SMA Kota Tarakan, 31 Oktober-2 November 2008*

[12] Santyasa I W 2008 Pembelajaran Berbasis Masalah dan Pembelajaran Kooperatif *Makalah disampaikan dalam Pelatihan Pembelajaran dan Asesmen Inovatif bagi Guru-guru Sekolah Menengah Kecamatan Nusa Penida, Bali, 22-24 Agustus 2008*

[13] Sudibyo E 2016 Model Pembelajaran Untuk Menumbuhkan Motivasi Belajar, Meningkatkan Pemahaman Konsep Fisika dan Keterampilan Berfikir Analitis Mahasiswa Ilmu Keolahragaan *Disertasi* (Surabaya: Pasca Sarjana Unesa)

[14] Menteri Pendidikan dan Kebudayaan Republik Indonesia 2013 *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 73 tahun 2013 tentang Penerapan Kerangka Kualifikasi Nasional Indonesia Bidang Perguruan Tinggi* (Jakarta: Kemendikbud.)

[15] Arends R L 2012 *Learning to Teach* (New York: Mc.Graw-Hill Book Corporation)

[16] Hu W and Adey P 2002 *Int. J. Sci Educ.* **24 (4)** 389

[17] Akker J V D, Gravemeijer K, McKenney S and Nieveen N 2006 The value of variety *Educational Design Research* eds Akker J V D, Gravemeijer K, McKenney S and Nieveen N (New York: Routledge) chapter 10 pp 151-158

[18] Plomp T 2010 Educational design research: an introduction *An Introduction to Educational Design Research* eds Plomp T and Nieveen N (Netherlands: Netzodruk, Enschede) chapter 1 pp 9-34