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Project based laboratory learning as an alternative learning model to improve sciences process skills and creativity of physic teacher candidate

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Project based laboratory learning as an alternative learning model to improve sciences process skills and creativity of physic teacher candidate

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Abstract. The Project Based Laboratory Learning (PjBLL) model is designed to improve the process skills and creativity of physics teacher candidates who meet practical and effective criteria. The model was developed using the Plomp design through the preliminary study, prototype stage, and assessment phase. The study design used one-group pretest-posttest design. The research subjects were 64 grade B and C physics students who were programmers in Unesa's laboratory. Data is collected through assessment of expert validity, observation, tests, documentation, interviews, and questionnaires. Data is analysed using qualitative and quantitative descriptive statistics, N-gain and paired t-test. The results of the study show that: (1) the PjBLL model developed is included in practical category because the component model can be implemented in learning activities well, without significant constraints. (2) The PjBLL model developed is included in the effective category because the student's process skills are improving in the medium criteria with an average N-gain of 0.58, students are able to produce creative products with a mean N-gain of 0.56, and students respond positively to the device and learning process. The implementation of the PjBLL model needs to be expanded to provide greater support for the practicality and effectiveness of the model. Based on the above, it can be concluded that the PjBLL model developed is practical and effective to improve the process skills and creativity of physics teacher candidates.

Key words: PjBLL, learning model, process skills, creativity, physics teacher candidates.

1. Introduction

The effort to create competent physics teacher candidates is still a major problem in the world of education in Indonesia [1]. The learning process that is still product oriented and memorization makes process skills and creativity development tend to be ignored [2]. The process skills of the 2014 students of Biology, Physics and Chemistry S1 Unesa FMIPA have not reached 60; because they are less competent in planning and carrying out experiments with the correct procedure [3]. The value of certain process skills such as observation, manipulating variables, and controlling variables is still below 50 (range of scores 0-100). In addition, the product of the creativity produced by students is still limited to creative and imaginative ideas, so it is necessary to improve the quality and usefulness of creative products in real life [4]. Practical instructions as a creative product of students that contain process skills (formulating problems, formulating hypotheses, identifying variables, defining operational variables, designing data tables, designing procedures, analyzing data, drawing conclusions) were still low since 1982 until now [5,6 , 3,8]. This is consistent with the results of the researchers' preliminary study that students are still finding problems in completing the tasks of physics laboratory courses, including: (1) lack of basic concepts and basic skills in laboratory material, (2) lack of skills in identifying laboratory problem in physics learning and the solution technique, (3) the design of the equipment produced by students is largely unable to meet the standards of science teaching aids, and (4) the design of equipment made by students cannot be operationalized for practical activities. Therefore, various efforts are needed to improve the process skills and creativity of students in physics laboratory courses [9].

Various efforts have been made in maximizing the role of physics laboratory courses to encourage students to produce contextual work either individually or in groups by applying Problem Based

Learning (PBL) and Project Based Learning (PjBL). PBL is able to improve the learning achievements of prospective physics teachers and enable them to educate students in teamwork and high research abilities [10]; improve the ability of students to understand physical phenomena, share knowledge, conduct research, solve various problems [11]. Primary and secondary school science teachers recognize the importance of PBL as an investigative approach that helps them explain the essential aspects of science [12]. The application of PBL to prospective physics teachers is faced with real problems and is expected to be used and developing PBL's basic abilities to solve authentic problems, construct their own knowledge, develop inquiry and higher-order thinking skills, and develop self-reliance and self-confidence [13]. Learning in physics laboratory courses also uses PjBL to help students explore, evaluate, interpret, synthesize, and inform to produce creative products. PjBL uses project problems as a first step to gather and integrate new knowledge based on student experience in actual activities.

This study seeks to develop the Project Based Laboratory Learning (PjBLL) model as an PBL and PjBL model innovation that emphasizes the importance of process skills and the development of student creativity as a key element of learning success in physics laboratory courses. The development of process skills is emphasized on indicators such as formulating problems, formulating hypotheses, identifying variables, making operational definitions of variables, designing data tables, designing experimental procedures, analyzing data, and drawing conclusions. Creativity is emphasized on creative individual, creative process, creative product, and creative environment; but in this study the instructional goals are emphasized on creative individuals and creative products, while the creative process and creative environment are the companion goals. This is because process skills contribute directly and significantly to the creative process, and the creative environment is a major component of the PjBLL model. Creativity is emphasized on fluency, flexibility, and originality indicators. In line with [14]; creativity in learning physics known as scientific creativity has similarities with creativity in general in terms of fluency, flexibility, and originality; but stressed on creative science experiments, finding problems and solving scientific problems creatively, and creative scientific activities. In addition, the creative product quality result is emphasized on the suitability of the material with the real needs in the school, the appropriateness of the equipment for experimentation, the practicality of manipulating variables, the accuracy of data measurements, the practicality of recording data, product aesthetics, and product safety. The development of the PjBLL is in line with the IQF in the Field of Higher Education and National Higher Education Standards [15,16,17,18]. The quality of the PjBLL model is developed by practicality and effectiveness criteria.

The problems that will be answered are (1) how will the practicality of the PjBLL model that has been developed improve the process skills and creativity of physics teacher prospective students in terms of the implementation of the model and what obstacles are faced when applied? (2) how effective is PjBLL model that has been developed to improve the process skills and creativity of prospective physics teacher students in terms of improving process skills and creativity as well as how student will response to the learning tools and processes with PjBLL model?

2. Research Methods

Research on the PjBLL model along with its supporting devices was adapted from the Model [19] including the Research and Development research types divided into three main stages, namely preliminary research, prototype development, and assessment. Preliminary research and prototype development have been carried out [20]. The target of the study was 64 students of class B and C physics education study programs who programed physics laboratory courses in the 2015/2016 academic year at Surabaya State University. The research design uses single group design, one group pretest-posttest that is replicated.

O_1	X	O_2

Figure 1. Research Design [21]

Description: O1 = The initial test is carried out before the implementation of the PjBLL
O2 = The final test is done after the PjBLL model is applied
X = Treatment using the PjBLL model

The model implementation data was measured using the PjBLL Implementation Observation Instrument. Observations were made by two observers during the learning process in 12 meetings by giving an assessment of lecturing activities with the PjBLL model (motivating student independence in the project, organizing student needs in the project, guiding project investigations in groups, monitoring student creativity in developing projects, presenting and evaluating products creative, evaluating and reflecting) by giving a checklist (□) in the assessment column 1-4 on the instrument which is considered most appropriate. Data on learning implementation constraints is measured using Observation Instruments Learning Constraints. The assessment was carried out by two observers by noting the obstacles to the learning implementation that came from students, lecturers, tools and materials, or other conditions.

Process skill data was measured using the Process Skill Test Instrument. The test item consists of 8 items, where each question represents the indicators formulating the problem, formulating hypotheses, identifying variables, defining operational variables, designing data tables, designing experimental procedures, analyzing data, and drawing conclusions. Process skills tests are done by students before and after the learning process. Data on creativity as a creative individual was measured using the Creativity Questionnaire Instrument which consist of 18 positive and negative statements to find out the students attitude in making teaching aids along with technical instructions in terms of aspects of fluency, flexibility, and originality. Implementation data of the PjBLL model were analyzed descriptively qualitatively by comparing the mean scores of the two observers. The reliability of the observations on the implementation of the PjBLL model is calculated using the percentage of agreement formula. The observations are said to be reliable if the reliability value is □ 75% [21]. The level of improvement in process skills is calculated using N-gain [21]. The initial test data and the final test process skills are then carried out using homogeneity tests, normality tests, and inferential statistical tests with the help of SPSS. Statistical tests are using paired t-test.

The obstacles found during learning implementation can come from students, lecturers, tools, materials, media, or other conditions that hinder learning with the PjBLL model analyzed descriptively qualitatively so that alternative solutions are found to improve the PjBLL model were along with the devices developed. The response data is the opinion of prospective physics teacher students about the device novelty, the learning process, the clarity of the lecturer in teaching, and the ease of students in learning. The response data was obtained after the learning process was analyzed quantitatively using the percentage.

3. Research Results

The practicality of the PjBLL model was viewed from the implementation of the model phases along with the constraints of their implementation in the extensive trial. The implementation of the RPS in a broad trial illustrates the activities of lecturers in carrying out the learning process in a broad trial referring to the phases of the PjBLL model. Observation of the implementation of the PjBLL model is carried out by 2 observers by observing; Motivating the independence of students in the project; organizing student needs in the project; guiding project investigate in groups; monitor student creativity in developing projects; presenting and assessing creative products; evaluating and reflecting. The results of observations on the implementation of the PjBLL model phases in class B and class C from meetings 1 to 12 have good and very good criteria. This means that the lecturer is able to carry out learning activities according to the RPS scenario. In addition, the reliability coefficient is above 75% so the results of observing RPS implementation in criteria are reliable. The implementation of the PPjL model at the beginning of the meeting was also still found with several technical and non-technical constraints, but various obstacles that were found were finally resolved at the end of the meeting. Furthermore, a number of alternative solutions are given as a recommendation for future researchers. The effectiveness of the PjBLL model is viewed from the improvement of process skills, creativity, and student responses to the implementation of the PjBLL model and its supporting devices in a broad trial. A summary of the results of the process skills tests before and after students take part in the learning process in a broad trial is presented in Table 1.

Table 1. Indicator completeness and N-gain process skills

Class	Indicator Process Skills	Pretest				Posttest				*N-Gain*	
		Score	Completeness			Score	Completeness				
			Σ	%	Ket		Σ	%	Ket	<g>	Inf.
B	Formulation of the problem	46,88	8	25,00	TT	78,13	28	87,50	T	0,59	middle
	Formulation of the hypothesis	40,63	5	15,63	TT	80,47	27	84,38	T	0,67	middle
	Identify variables	42,97	4	12,50	TT	74,22	25	78,13	T	0,55	middle
	Variable operational definition	27,34	3	9,38	TT	72,66	26	81,25	T	0,62	middle
	Design the observation table	30,47	4	12,50	TT	73,44	25	78,13	T	0,62	middle
	Designing procedures	28,91	3	9,38	TT	69,53	22	68,75	TT	0,57	middle
	Data analysis	53,91	9	28,13	TT	79,69	28	87,50	T	0,56	middle
	Draw a conclusion	64,84	20	62,50	TT	78,13	28	87,50	T	0,38	middle
C	Formulation of the problem	44,53	2	6,25	TT	78,91	27	84,38	T	0,62	middle
	Formulation of the hypothesis	40,63	0	0,00	TT	80,47	28	87,50	T	0,67	middle
	Identify variables	39,06	2	6,25	TT	75,78	27	84,38	T	0,60	middle
	Variable operational definition	25,00	3	9,38	TT	74,22	28	87,50	T	0,66	middle
	Design the observation table	25,78	3	9,38	TT	74,22	27	84,38	T	0,65	middle
	Designing procedures	25,00	1	3,13	TT	64,06	17	53,13	TT	0,52	middle
	Data analysis	50,78	9	28,13	TT	78,91	29	90,63	T	0,57	middle
	Draw a conclusion	67,19	23	71,88	TT	78,13	27	84,38	T	0,33	middle

Description: T = Completed, TT = Not Complete

Table 4. shows that the application of PjBLL can improve the completeness of process skill indicators in class B and class C which were previously incomplete (0%) to 87% complete; all indicators have been completed except designing experimental procedures. This is because some students still have difficulty in designing experimental procedures precisely, especially making experimental design drawings. However, the acquisition of an N-gain value indicates the increasing level in each indicator of process skills in the medium criteria.

Student creativity data were obtained from the results of the assessment of creative products produced by each group and the results of student creativity questionnaires. Student creativity data is presented below.

Table 2. Results of Assessment of Student Creative Products

Class	Creative Product Indicators	Group							
		1		2		3		4	
		Score	Inf.	Score	Inf.	Score	Inf.	Score	Inf.
B	1. Relevance to real needs	75	B+	75	B+	75	B+	75	B+
	2. Feasibility of experimental equipment	75	B+	75	B+	100	A	100	A
	3. Practical manipulation of variables	75	B+	75	B+	75	B+	75	B+
	4. Accuracy of data measurement	75	B+	75	B+	100	A	75	B+
	5. The practicality of recording data	100	A	75	B+	75	B+	75	B+
	6. Product aesthetics	75	B+	75	B+	50	D	100	A
	7. Product safety	75	B+	75	B+	75	B+	75	B+
	8. The authenticity of the product	75	B+	75	B+	100	A	75	B+
C	1. Relevance to real needs	75	B+	75	B+	75	B+	100	A
	2. Feasibility of experimental equipment	100	A	75	B+	75	B+	75	B+
	3. Practical manipulation of variables	100	A	100	A	100	A	75	B+
	4. Accuracy of data measurement	100	A	75	B+	100	A	100	A
	5. The practicality of recording data	100	A	75	B+	100	A	75	B+

6. Product aesthetics	75	B+	100	A	75	B+	100	A
7. Product safety	75	B+	75	B+	100	A	75	B+
8. The authenticity of the product	100	A	75	B+	75	B+	75	B+

Table 2. shows students of class B and C are able to produce creative products well; because all aspects of creative product assessment include the relevance of material with real needs in school, the appropriateness of equipment for related material experiments, practicality in manipulating variables, accuracy in measuring data, practicality in recording data, product esthetics, product safety and authenticity get a minimum B + rating criteria; except for group 3 in class B the aesthetic value of the product is still found in criterion D.

This is reinforced data from the creativity questionnaire results before and after learning presented in Table 3.

Table 3. Completeness of Student Creative Personal Indicators

Class	**Indicator**	**Early Questionnaire**				**Final Questionnaire**				***N-Gain***	
		Score	**Completeness**			**Score**	**Completeness**				
			Σ	**%**	**Inf.**		**Σ**	**%**	**Inf**	**<g>**	**Inf.**
B	Smoothness	56,64	11	34,38	TT	76,69	28	87,50	T	0,46	middle
	Flexibility	53,13	5	15,63	TT	73,83	27	84,38	T	0,44	middle
	Originality	41,54	2	6,25	TT	66,80	26	81,25	T	0,43	middle
C	Smoothness	51,82	10	31,25	TT	73,05	28	87,50	T	0,44	middle
	Flexibility	51,30	6	18,75	TT	70,57	27	84,38	T	0,40	middle
	Originality	46,22	3	9,38	TT	68,36	26	81,25	T	0,41	middle

Description: T = Completed, TT = Not Complete

Table 3. shows that the application of PjBLL in class B and C is able to improve the completeness of creative individual indicators that previously have not been completely completed. N-gain value of the level improvement of each creative individual indicator is in the criteria of being. Then the SPSS assisted similarity test was carried out which began with a prerequisite test for normality and homogeneity. The prerequisite test results show the scores of the initial questionnaire and the final questionnaire scores in class B and class C are normal and homogeneous, so that in each class a paired t-test is applied. Data from t-test results in class B and class C show pairs of -68.2 and -66.4 respectively. With degrees of freedom (df) = 31; t score of each class gives a value of -31.2 and -32.4 with a significance value of $p < 0.05$. This indicates a significant increase in the creative personality of students before and after the PjBLL model was applied in both classes.

The results of the student response showed that the majority of Class B and Class C students felt new to the learning process carried out by lecturers, teaching methods, lab manuals, learning atmosphere; clarity of teaching lecturers (model phases, guiding process skills, facilitating creativity development); and easy learning (applying process skills, developing creativity, working on LP). Thus, class B and class C students respond positively to the PjBLL model and the learning process.

4. Conclusion

The Project Based Laboratory Learning model that was developed is practical and effective so that it is feasible to improve the process skills and creativity of prospective physics teacher students. The PjBLL model developed is practical, because its components can be carried out in extensive trial activities well and without significant obstacles.

The PjBLL model that was developed included in effectiveness, because: (1) improvement of student process skills in a broad trial significantly in the medium criteria; (2) the improvement of student creativity in the broad trial is significantly in the medium criteria. In addition, students are able to produce creative products in the form of physical teaching aids along with technical instructions; and (3) students give a positive response to the device and the learning process.

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