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To cite this article: Dwikoranto *et al* 2020 *J. Phys.: Conf. Ser.* **1569** 042066

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Increasing the Potential of Student Science Process Skills Through Project Based Laboratory

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Abstract. The Project Based Laboratory Learning (PBL) model is designed to improve the process skills 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 32 grade B and 32 grade C physics students who were programmers in Unesa's laboratory. Data is collected through assessment of observation, tests, 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 PBL model developed is included in practical category because the component model can be implemented in learning activities well, without significant constraints. (2) The PBL model developed is included in the effective category because the student's process skills are improving in the medium criteria and students respond positively to the device and learning process. The implementation of the PBL 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 PBL model developed is practical and effective to improve the process skills of physics teacher candidates.

1. Introduction

Process skills include theoretical concepts that are very important in learning physics because these skills enable a student to produce meaningful information from his own observations and experiences, and they can develop skills while learning scientific information and doing good science activities [1]. The development of process skills makes it easier for students in the process of scientific inquiry [2,3].

Science process skills can be classified into basic skills and integrated skills [4,5,6,7,8]. Science process skills, both basic and integrated, must be trained for students and students so that students and students are not only recipients of information, but also can search for information related to the things being learned.

Included in the categories of basic science process skills are: observing, classifying, measuring, communicating, inferring, predicting. While those included in integrated science process skills are: formulating hypotheses, naming variables, controlling variables, making operational definitions, experimenting, interpreting, investigating, applying concepts [9,4,5,6,7,8].

Low initial student science process skills will hinder the learning process of physics in the classroom [4,10,11,12]. Important process skills are owned by students and are used in learning physics. Lecturers are required to train and improve their process skills to students as provisions for teaching. Process skills include the basic skills needed by students to understand physics like a scientist [13].

The science process skills test of students majoring in Biology, Physics, and Chemistry FKIE IKIP Bandung, Surabaya, Yogyakarta and Ujung Pandang obtained an average proportion of correct answers of 0,46. Students have not been able to plan experiments correctly. The proportion of correct answers 0.03 means that from 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 [14].

The science process skills test at FMIPA Unesa against S1 Biology, Physics and Chemistry students in class of 2014 has not reached 60. Not yet competent in planning and carrying out experiments. There are indications they are carrying out experiments with procedures that are not yet correct. This indication is reinforced by the value of certain aspects of the science process skills such as observation, manipulation of variables, and controlling variables under 50. Even controlling the fourth variable is under 40 [15].

The low value of PPP above is confirmed by international studies that Indonesia is one level below Brazil and one level above Tunisia. Indonesia ranks 39th out of 40 countries in the world [16]. The method for conducting scientific investigations using scientific process skills is known as the scientific method [17,18,19,20]. Process skills as procedural, experimental, and systematic scientific inquiry skills as a basis for scientific scientific literacy [8,21].

It is important to prepare students to effectively use the tools available that they will use during collaborative learning activities in classrooms with certain models [22]. The development of process skills greatly facilitates students in scientific activities through observation and scientific inquiry to explore and find information. Problem based laboratory learning (PBL) is needed to overcome barriers to use Problem based learning in a broader scope, overcoming the lack of use in a large scope of information [23,24] is needed to overcome the low ability of investigations for problem solving [25] and providing feed back learning [26]. In the PBL model there is a phase guiding group project investigations to understand science process skills as the basic skills needed in learning.

2. Research Methods

The study design used a quasi-experimental one group pretest-posttest which is presented below.

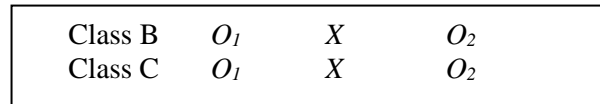


Figure 1. Research Design [27]

Note: O_1 = Initial test is done before implementing the PBL model; O_2 = Final test carried out after applying the PBL model; X = Treatment using PBL model.

The research subjects were conducted on 32 students of class B and 32 students of class C in physics education study programs who program physics laboratory courses in the academic year 2017/2018. The study was conducted in February to June 2018 in Unesa Physics Education Study Program.

Process skills data were measured using the Science Process Skills Test Instrument in the form of essay questions. The test items consist of 8 items, each of which represents 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 undertaken by students before and after the learning process; then the students' answers are assessed by referring to the rubric on the scale 0-4. The acquisition of the above values is adjusted to the rating criteria in Table 1.

Table 1. Criteria for Process Skills Assessment [28]

Score	Assessment criteria	Score	Assessment Criteria
$85 \leq \text{skor} < 100$	A	$60 \leq \text{skor} < 65$	C+
$80 \leq \text{skor} < 85$	A-	$55 \leq \text{skor} < 60$	C
$75 \leq \text{skor} < 80$	B+	$40 \leq \text{skor} < 55$	D
$70 \leq \text{skor} < 75$	B	$0 \leq \text{skor} < 40$	E
$65 \leq \text{skor} < 70$	B-		

Students are said to be complete indicators of process skills if the value of process skills is at least 60 with criterion C. Completion of indicators is classically achieved if 85% of students reach the indicator

completion level. Students understand the indicator if the indicator value is at least 2.00 and the completeness of the indicator is achieved if 75% of students have mastered the process skills indicator. The level of improvement in process skills is calculated using N-gain [28]. The acquisition of N-gain is adjusted to the rating criteria in Table 2.

Table 2. Criteria *N-Gain*

Score <i>N-Gain</i>	Criteria
$0,70 < N-Gain$	High
$0,30 \leq N-Gain \leq 0,70$	medium
$N-Gain < 0,30$	low

Initial test data and final process skills test were then carried out homogeneity tests, normality tests, and inferential statistical tests with the help of SPSS. Statistical tests use paired (parametric) t-tests and Wilcoxon (non-parametric) tests. In hypothesis testing using a significance level $\alpha = 5\%$ (two-tailed).

3. Research Results

Results of Mastery of Science Process Skills in Class B and C Students during the initial test before treatment and the final test after treatment can be seen in Table 3 and Table 4 below.

Table 3. Mastery Process Skills of Class B

No	Pre test					Post test					<i>N-Gain</i>
	Score	Inf	Completeness criteria		Score	Ket	Completeness criteria		<g>	Ket	
			Individual	classical			Individual	classical			
M1	40,63	D	TT	13%	71,88	B	T	97%	0,53	Medium	
M2	43,75	D	TT	Tidak Tercapai	78,13	B+	T	Tercapai	0,61	Medium	
M3	37,50	E	TT		78,13	B+	T		0,65	Medium	
M4	50,00	D	TT		78,13	B+	T		0,56	Medium	
M5	34,38	E	TT		84,38	A-	T		0,76	Tinggi	
M6	43,75	D	TT		84,38	A-	T		0,72	High	
M7	46,88	D	TT		78,13	B+	T		0,59	Medium	
M8	50,00	D	TT		71,88	B	T		0,44	Medium	
M9	25,00	E	TT		78,13	B+	T		0,71	High	
M10	34,38	E	TT		81,25	A-	T		0,71	High	
M11	50,00	D	TT		75,00	B+	T		0,50	Medium	
M12	34,38	E	TT		84,38	A-	T		0,76	High	
M13	40,63	D	TT		75,00	B+	T		0,58	Medium	
M14	65,63	B-	T		71,88	B	T		0,18	Low	
M15	43,75	D	TT		75,00	B+	T		0,56	Medium	
M16	31,25	E	TT		78,13	B+	T		0,68	Medium	
M17	65,63	B-	T		71,88	B	T		0,18	Low	
M18	56,25	C	TT		81,25	A-	T		0,57	Medium	
M19	34,38	E	TT		81,25	A-	T		0,71	High	
M20	34,38	E	TT		71,88	B	T		0,57	Medium	
M21	34,38	E	TT		81,25	A-	T		0,71	High	
M22	31,25	E	TT		65,63	B-	T		0,50	Medium	
M23	65,63	B-	T		71,88	B	T		0,18	Low	
M24	43,75	D	TT		78,13	B+	T		0,61	Medium	
M25	46,88	D	TT		75,00	B+	T		0,53	Medium	
M26	65,63	B-	T		81,25	A-	T		0,45	Medium	
M27	34,38	E	TT		68,75	B-	T		0,52	Medium	
M28	21,88	E	TT		65,63	B-	T		0,56	Medium	
M29	40,63	D	TT		68,75	B-	T		0,47	Medium	
M30	31,25	E	TT		56,25	C	TT		0,36	Medium	
M31	34,38	E	TT		75,00	B+	T		0,62	Medium	
M32	31,25	E	TT		87,50	A	T		0,82	High	

Note: T = Completed, TT = Not Completed

Table 4. Mastery Process Skills of Class C

No	Pre test			Post test			N-Gain			
	Score	Inf.	Completeness indicator		Score	Inf.	Completeness indicator			
			Individual	classical			Individual	Classical	<g>	Inf.
M1	40,63	D	TT	3%	65,63	B-	T	94%	0,42	Medium
M2	40,63	D	TT	Tidak Tercapai	78,13	B+	T	Tercapai	0,63	Medium
M3	25,00	E	TT		78,13	B+	T		0,71	High
M4	34,38	E	TT		78,13	B+	T		0,67	Medium
M5	40,63	D	TT		75,00	B+	T		0,58	Medium
M6	34,38	E	TT		84,38	A-	T		0,76	High
M7	43,75	D	TT		71,88	B	T		0,50	Medium
M8	43,75	D	TT		71,88	B	T		0,50	Medium
M9	25,00	E	TT		43,75	D	TT		0,25	Low
M10	34,38	E	TT		81,25	A-	T		0,71	High
M11	53,13	D	TT		81,25	A-	T		0,60	Medium
M12	40,63	D	TT		87,50	A	T		0,79	High
M13	37,50	E	TT		81,25	A-	T		0,70	Medium
M14	68,75	B-	T		71,88	B	T		0,10	Low
M15	46,88	D	TT		68,75	B-	T		0,41	Medium
M16	34,38	E	TT		78,13	B+	T		0,67	Medium
M17	59,38	C	TT		78,13	B+	T		0,46	Medium
M18	46,88	D	TT		87,50	A	T		0,76	High
M19	21,88	E	TT		90,63	A	T		0,88	High
M20	28,13	E	TT		75,00	B+	T		0,65	Medium
M21	40,63	D	TT		84,38	A-	T		0,74	High
M22	40,63	D	TT		81,25	A-	T		0,68	Medium
M23	50,00	D	TT		75,00	B+	T		0,50	Medium
M24	37,50	E	TT		75,00	B+	T		0,60	Medium
M25	43,75	D	TT		71,88	B	T		0,50	Medium
M26	46,88	D	TT		68,75	B-	T		0,41	Medium
M27	40,63	D	TT		78,13	B+	T		0,63	Medium
M28	34,38	E	TT		68,75	B-	T		0,52	Medium
M29	40,63	D	TT		62,50	C+	T		0,37	Medium
M30	31,25	E	TT		59,38	C	TT		0,41	Medium
M31	28,13	E	TT		75,00	B+	T		0,65	Medium
M32	37,50	E	TT		90,63	A	T		0,85	High

Note: T = Completed, TT = Not Completed

Table 3. and Table 4. show the process skills of students in class B and class C were initially low; because all students have E / D grades, except 4 students of class B (M14, M17, M23, M26) have grades B and 1 student of class C (M14) have grades B. Conversely, the process skills of students after applying the PBL model is getting better; because all students in class B and class C get A / B grades, except for 1 class B (M30) student and 3 class C students (M9, M29, M30) still get C / D grades. The application of the PBL model was proven to be able to increase classical completeness in class B which was originally 13% (incomplete) to 97% (complete) and class C which was originally 3% (incomplete) to 94% (complete). This is reinforced by the value of N-Gain process skills in both classes generally in the medium / high criteria; except 3 group II students (M14, M17, M23) and 2 group III students (M9, M14) in the low criteria. The SPSS-assisted equality test is then performed which begins the prerequisite tests for normality and homogeneity. The test results show the initial test scores and final test scores of class B and class C meet the requirements of normality and homogeneity, so that in each class paired t-tests are selected whose results are presented in Table 5.

Table 5. Results of Paired Skill T-Test Results

N	Uji-t Berpasangan				
	Mean	Std. Deviation	t	Df	P
32	-72,6	12,8	-32,3	31	<0,00
32	-67,9	15,2	-30,6	31	<0,00

Note: $p < 0,05$ (two-tailed)

Table 5. shows the mean data of paired t-test results in class B and class C respectively -72.6 and -67.9. With degrees of freedom (df) = 31; the t score of each class gave a value of -32.3 and -30.6 with a significance value of $p < 0.05$. This indicates a significant increase in process skills before and after the PBL model is applied to both classes. Table 5. shows the mean data of paired t-test results in class B and class C respectively -72.6 and -67.9. With degrees of freedom (df) = 31; the t score of each class gave a value of -32.3 and -30.6 with a significance value of $p < 0.05$. This indicates a significant increase in process skills before and after the PBL model is applied to both classes.

The practicality of the PBL model was viewed from the implementation of the model phases along with the constraints of their implementation in the extensive trial. The implementation of model 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 PBL model. Observation of the implementation of the PBL 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 PBL 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 scenario. In addition, the reliability coefficient is above 75% so the results of observing implementation in criteria are reliable. The implementation of the PBL 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 PBL model is viewed from the improvement of process skills, creativity, and student responses to the implementation of the PBL model and its supporting devices in a broad trial.

Motivating the independence of students in the project as part of PBL has made aware of the importance of being creative and independent individuals in supporting the success of physics learning activities, practicing process skills, and project assignments to be carried out according to metacognition theory [29,30] that when students feel self-aware as learners who actively monitor learning strategies and their own knowledge can increase the transfer of material learned in new situations. The application of metacognition in physics laboratory courses makes information processing more automatic. The habit of creative and independent thinking makes it more possible for students to develop creative thinking; so they are able to generate new ideas, combine ideas in new ways, or unique problem solving [29].

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 6.

Table 6. Indicator completeness and N-gain process skills

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

Description: T = Completed, TT = Not Complete

Table 6. shows that the application of PBL 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.

When students have difficulty making operational definitions of variables, they will have difficulty in designing experimental procedures appropriately [8]. Strengthened the results of researchers' interviews with several students so that it was found several causes are they lack understanding of physics laboratory equipment, are less accustomed to designing experimental procedures, and find it difficult to form a series. This is consistent with the finding [31] that some student mistakes in designing the experimental procedure are the experimental procedures not yet equipped with the experimental picture, the steps of changing the manipulation variable are not quite right, the measurement of the response variable is not mentioned as a measurement tool or its unit. However, the application of the PBL model has proven to be able to improve the mastery of classical process skills. When students have difficulty making operational definitions of variables, they will have difficulty in designing experimental procedures appropriately [8]. Strengthened the results of researchers' interviews with several students so that it was found several causes are they lack understanding of physics laboratory equipment, are less accustomed to designing experimental procedures, and find it difficult to form a series. This is consistent with the finding [31] that some student mistakes in designing the experimental procedure are the experimental procedures not yet equipped with the experimental picture, the steps of changing the manipulation variable are not quite right, the measurement of the response variable is not mentioned as a measurement tool or its unit. However, the application of the PBL model has proven to be able to improve the mastery of classical process skills.

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 worksheet). Thus, class B and class C students respond positively to the PBL model and the learning process.

4. Conclusion

The PBL model developed is included in practical category because the component model can be implemented in learning activities well, without significant constraints. The PBL 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, and students respond positively to the device and learning process. PBL model developed is practical and effective to improve the process skills of physics teacher candidates. The implementation of the PBL model needs to be expanded to provide greater support for the practicality and effectiveness of the model.

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