

Project-Based Learning in Programmable Logic Controller

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Abstract. Project-based learning is a learning method that uses project activities as the core of learning and requires student creativity in completing the project. The aims of this study is to investigate the influence of project-based learning methods on students with a high level of creativity in learning the Programmable Logic Controller (PLC). This study used experimental methods with experimental class and control class consisting of 24 students, with 12 students of high creativity and 12 students of low creativity. The application of project-based learning methods into the PLC courses combined with the level of student creativity enables the students to be directly involved in the work of the PLC project which gives them experience in utilizing PLCs for the benefit of the industry. Therefore, it's concluded that project-based learning method is one of the superior learning methods to apply on highly creative students to PLC courses. This method can be used as an effort to improve student learning outcomes and student creativity as well as to educate prospective teachers to become reliable educators in theory and practice which will be tasked to create qualified human resources candidates in order to meet future industry needs.

1. Introduction

Learning that has more impact on improving learning outcomes are student-centered learning [1]. One of the student-centered learning methods is the project-based learning method. Project-based learning begins with a task to perform one or more tasks that lead to the production of the final product [2, 3]. Student participation in project work encourages creativity, critical thinking, and teamwork [4]. PLC learning discusses the design, assembly, and programming of an electronic-based control system using a fairly complicated logic. But the tendency is the students just memorize the concept alone without a thorough understanding of the subject matter. How to learn like this will not be able to create a candidate electrical engineering teacher who will be tasked to produce quality human resources to answer future needs.



Practical work is needed in the learning of electrical engineering education, because with practical work will make the students directly involved and have knowledge that is more meaningful than learning by memorizing. To overcome this problem some researchers have suggested some suitable learning methods to be applied in the learning of technical education such as problem-based learning [1], cooperative learning [5-8] and project based learning [9]. Although some of the preferred learning methods provide good results the application of such learning methods should be supported with adequate laboratory facilities while existing conditions do not support them.

The aims of this study is to investigate the influence of project-based learning methods on students with a high level of creativity in learning the PLC. The application of project-based learning methods with observe to the level of creativity of students on PLC course is intended to provide experience for students who can become skill as well as knowledge so that after studying PLC courses students can achieve optimal learning outcomes [10] or understand the concept and practice of automatic control process even in the implementation of the learning process has limitations on the availability of laboratory equipment. However, in the application of this method of learning, the problem is found that the availability of practicum tools that have not been adequate. In the application of this methods of learning, to overcome the problem lack of tools in our laboratory make a practical supporting tool in the form of board trainer to facilitate practical work of the students in studying PLC. Unlike other PLC laboratory equipment, this board trainer is so simple that it can help students through the application of project-based learning methods to better understand the completion of PLC design, assembly and programming projects. This board trainer renewal makes the implementation of project-based learning methods suitable for application in developing countries with various limitations in the field of learning facilities and infrastructure.

2. Methods

The method used in this research is an experimental method with care design at level 2 x 2. Dependent variable is Student learning outcomes in the course of PLC, the independent variables are 1) learning methods consisting of project-based learning methods and simulation learning methods, 2) the level of student creativity, differentiated with high and low creativity.

The population in this study is sixth-semester students majoring in electrical engineering education, faculty of Engineering Universitas Negeri Manado academic year 2014/2015 with total 80 people. The sample in this study followed the recommendation from Popham that high and low groups were selected by selecting 30% [11] from 80 students of which 24 students with high creativity divided by 2, so 12 students entered the experimental class with the treatment of project-based learning methods and 12 other students entered the control class with Treatment of simulated learning method, as well as 24 students who have low creativity level. This research was conducted at the Department of Electrical Engineering faculty of Engineering Universitas Negeri Manado in Tondano which lasted for 1 semester which runs on the even semester from January to the beginning of July 2015.

The technique of collecting learning result data is obtained through the test of learning result which consists of 50% written test and 50% practice test. The written test is in form 30 objective questions, with weight 1 for correct answer and 0 for the wrong answer, while for practice test is taken through observation sheet with maximum score 3 for best condition and 0,6 for bad state, as well as techniques of collecting student creativity data obtained through a creativity questionnaire consisting of 30 statements using a scale of 1-5.

Validity test is done in two forms, namely testing the validity of constructs/content and testing of empirical validity. Testing the validity of the constructs/contents is done with expert analysis and empirical validity testing with the correlation of grain scores with the total score of test results test. Team experts for analysis the test of learning outcomes is: Prof. Dr. Ph. Tuerah, M.Si DEA, Prof. Dr. H. Sumual, M.Si, Dr. Ir. V. R. Palilingan, M.Eng, and for the instrument of creativity is Prof. Dr. Yufiarti and Dr. Syuul T. Karamoi, M.Si, Respondents expert review consists of Respondents were asked to provide an assessment of learning outcomes on the following aspects: 1) Question item according to indicator, 2) Problems are clearly defined, 3) The language domain, 4) The formulation

of a sentence does not give rise to a double understanding, 5) Material compatibility. After testing the validity of the construct followed by empirical validity testing. The test of the instrument is carried out on the students majoring in electrical engineering education with the number of 30 students in the semester VIII who have passed the PLC courses. Implementation of test questions carried out before the implementation of the experiment and who conducted the trial is a researcher and assisted by a team of lecturers majoring in electrical engineering education. The formula used to test the validity of written test learning result is the correlation of biserial point, and for practice test is product moment correlation, and for creativity instrument is product moment correlation. The conclusion of the test results of validity of the instrument written test learning results are 30 valid questions and 2 invalid questions that are the number 25 and 29, and for practice test is stated all valid items, as well the results of validity test of creativity instrument there are 30 items valid and 6 invalid items are questioned number 6, 7, 8, 11, 30, 34. In this research, internal reliability test is done once and using one instrument the formula used for the written test is Kuder-Richardson 21, as well Reliability test used for product/practice test and creativity instrument is a coefficient of Alpha. The results of the reliability test of the written test show the high reliability because is the value of $r_{11} = 0.87884$, for product/practice test show high reliability because is the value of $r_{11} = 0.75369$, and creativity test showed the reliability is very high because the value of reliability test is 0.8187656.

Data analysis used in this research include descriptive analysis, prerequisite test analysis, and inferential analysis. Data to be analyzed with inferential statistics are assumed to be normally distributed. Normality test of data distribution is done by using Lilliefors test. Homogeneity measurements were performed to test data of groups A1B1, A2B1, A1B2, A2B2 using Bartlett test. Hypothesis testing was done by variance analysis technique of two variants of ANAVA and continued with the advanced test of Tukey test, with the aim to test the influence of learning method and creativity level to the learning result.

3. Results and discussion

The research data described is the score data of student learning outcomes. The data normality test is done on the data of learning result in eight data groups that are group A1, A2, B1, B2, A1B1, A1B2, A2B1, A2B2. Normality test of this data is done through Lilliefors test with significance level $\alpha = 0.05$. Result of normality test for group $A_1 = 0,1427$; $A_2 = 0,1269$; $B_1 = 0,1048$; $B_2 = 0,1180$; $A_1B_1 = 0,1468$; $A_1B_2 = 0,1681$; $A_2B_1 = 0,1303$; $A_2B_2 = 0,1683$; The normality test results from the eight data sets indicate $L_{count} < L_{table}$, which means accepting H_0 as well as it can be concluded that all data groups are normally distributed or it can be concluded that all groups of data come from normally distributed populations.

The homogeneity test was conducted using Bartlett Test. The data used in this analysis is the value of learning outcomes in eight groups of data that is group A1, A2, B1, B2, A1B1, A1B2, A2B1, A2B2. The result of the homogeneity calculation $\chi^2_{count} = 1,89952987 < \chi^2_{table} = 7,82$ so it is concluded that all populations have the same or homogeneous variance, thus the inferential statistical test requirements are met. Thus the requirements of inferential statistical tests are met and can be continued on hypothesis testing. The research hypothesis test used two-factor analysis of variance called Two Way ANOVA, with the aim to test the influence of main effect and interaction effect between the PLC learning result.

The result of calculated by two-lane variance analysis and the results of the calculation of hypothesis testing of the study are presented in the table 1.

Table 1. Two-Line ANAVA calculation result.

Source Varians	Dk	JK	RJK	F_h	F_{Table}	
					α 0,05	α 0,01
Inter Colom (A) (Learning Methods)	1	438,0225	438,0225	33,93**	4,06	7,24
Between Line (B) (Creative)	1	414,1875	414,1875	32,08**	4,06	7,24
Interaction	1	71,53	71,53	5,54*	4,06	7,24
Between Group	3	923,74	307,91	23,85**	2,82	4,26
In Group	44	567,83	12,91		-	-
Total Reduktion	47	1491,57			-	-

Description: * = Significant, ** = Very Significant

Based on the data in table 1, the results of two-way ANOVA calculation shows the results testing the effect of learning method on the learning outcomes of PLC, then obtained the value of $F_{count} = 33.93$ for the real level $\alpha = 0.05$ and $dk = 1$; 44 Obtained $F_{table} = 4.06$. If both values of F are compared then it is $F_{count} = 33.93 > F_{table} = 4.06$. The interaction hypothesis to be tested is the influence of interaction between the learning method and the level of creativity to the learning outcomes of PLC. Based on the results of interaction hypothesis testing as presented in table 1, which shows the results of testing the interaction of learning methods and creativity to the learning results of obtained $F_{count} = 5.54$ for the real level $\alpha = 0.05$ and $dk = 1$, 44 obtained $F_{table} = 4.06$. If both values of F are compared then the $F_{count} = 5.54 > F_{table} = 4.06$, which means H_0 is rejected and receives H_1 . This shows that there is an influence of learning method interaction with the level of creativity of student to learning result of PLC. These results show that the application of project-based learning methods and simulation learning methods provide different PLC learning outcomes when applied to students who have a high level of creativity and low creativity. Therefore, the hypothesis of interaction tested then further tested further to the simple hypothesis (simple effect).

Further testing of the simple hypothesis (simple effect) done on 2 hypotheses that is a test of simple hypothesis difference of learning result of PLC between all level of factor of a learning method and for each creativity factor. Tukey test calculation results are presented in the table 2.

Table 2. Results of advanced stage analysis with Tukey Test.

Comparison Group	n	K	dk	q_h	q_t	
					α 0,05	α 0,01
A ₁ B ₁ and A ₂ B ₁	12	4	3.44	8,187**	3,44	4,28
A ₁ B ₂ and A ₂ B ₂	12	4	3.44	3,472*	3,44	4,28

Based on the values in table 2 that shows the results of testing the effect of learning method based on high level of creativity to PLC learning results obtained $q_{count} = 8.187$. Using the real level $\alpha = 0.05$ and $dk = n - 2 = 24 - 2 = 22$, obtained $q_{table} (0.05: 22) = 3.44$. If both values of q are compared, then it turns out $q_{count} = 8.187 > q_{table} = 3.44$, which means H_0 is rejected and receives H_1 . Thus it can be concluded in the group of students who have high creativity, student learning outcomes PLC taught by project-based learning method is higher than the results of student learning taught by simulation learning method

Based on the values in table 2 which addressed the results of testing the effect of learning method based on the low level of creativity to PLC learning results obtained $q_{count} = 3.472$ by using the real level $\alpha = 0.05$ and $dk = n - 2 = 24 - 2 = 22$, obtained $q_{table} (0.05: 22) = 3.44$. If both values of q are compared, then it turns out $q_{count} = 3.472 > q_{table} (0.05: 22) = 3.44$ which means H_0 is rejected and receives H_1 . Thus it can be concluded that in groups of students who have low creativity, student learning outcomes of PLC taught with project-based learning methods is lower than the learning outcomes of PLC taught by simulation learning method.

The results of the study as described previously basically prove the project-based learning method is one superior learning method to apply on highly creative students to PLC course. The result of this analysis showing that the learning result of PLC group of students taught by project-based learning method is higher than a result of PLC learning group of students taught by simulation learning method. The results of this study prove that project-based learning is a learning that can stimulate learners to think critically [12] and create a flexible learning environment that can trigger the achievement of optimal learning outcomes. In learning of the PLC, students must become familiar with critical thinking because in automatic controllers design and programming suppose a structured logical arrangement to construct a single command in that controller's operation. With project work that is the heart of the application of project-based learning methods, the students has more enthusiastic to completing the project who had gave before, so that students know for themselves how to use the program who they has designed and built [13]. This shows their liveliness in learning has led them to build their skills as well as their knowledge in PLC learning [12], so it can be the engineers who are able to overcome industry problems and be able to face technical challenges in the future [14].

The result on this research is the application of project-based learning methods who treat by students with high creativity better than the application of simulation learning method in PLC learning outcomes. This is indicates that in the application of project-based learning methods are needed on student creativity, to generate brilliant ideas in designing and program in PLC learning. The result of this study are also similar with the research of Frank [15], where in the learning process students are required to complete a mini project and make a report, and the lecturers only provide direction at the initial meeting on how to prepare the mini project report and then to guide them to make a final report. This method can be students more competent to acquire skills through the experiences they discover during the learning process [15].

The challenge as a professional teacher candidate who will be tasked to bring golden generation to fulfil industry demand in the future will be achieved when the learning process that exist in electrical engineering education focuses on effective learning, that is learning who has a core on creativity development and decision making which are all there in project-based learning methods [16] which to focus on the attainment of skills and knowledge through direct student involvement in the learning process not only memorizing theories, but when student directly engage in the knowledge they experience will last longer in their memories and stimulate creativity they are working or completing design and programming PLC project better than just memorize PLC programming instructions.

The successful application of project-based learning methods to students with high creativity also lies in the ability of lecturers [17] to effectively designing the learning process, emphasizing motivation, and supporting their project work, guide them during the learning process that can reduce their doubts [18] to finding solution for finishing their project so that can be meaningful experience on skill or knowledge who will support their learning outcomes [4].

4. Conclusion

The application of project-based learning methods into the PLC courses combined with the level of student creativity enables the students to be directly involved in the work of the PLC project which gives them experience in utilizing PLCs for the benefit of the industry. Therefore, it's concluded that project-based learning method is one of the superior learning methods to apply to PLC courses. This method can be used as an effort to improve student learning outcomes and student creativity as well as to educate prospective teachers to become reliable educators in theory and practice which will be tasked to create qualified human resources candidates in order to meet future industry needs

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