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Submission date: 22-Jul-2021 05:48PM (UTC+0700)

Submission ID: 1622684384

File name: Sidik_2019_J._Phys._Conf._Ser._1387_012038.pdf (418.54K)

Word count: 3643

Character count: 20820



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To cite this article: Darlan Sidik and Nurul Hidayah Pratama ¹ 2019 *J. Phys.: Conf. Ser.* **1387** 012038

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Project-based learning intervention on the learning outcome of the analog electronics class to the electronics engineering education students

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Abstract. The main problems of this research were low quality of the interactions in learning and low achievement of the learning outcomes, especially in the reinforcement of Analog Electronics course material. This research aimed at describing the quality of implementation of an interactive and effective class which was based on competency (Learning Outcome). The method of this research was a quasi-experimental design using post-test and post-test only control group design on 32 respondents. The research results on the project-based learning model intervention with random sampling groups using a cognitive test (remembering and using) showed that the interactions and the learning outcomes outperformed those of the direct learning model. In conclusion, in order to improve the interaction and achievement of cognitive learning outcomes of the students in class, the project-based learning model intervention is better to implement by taking into account the steps or syntax of the project-based learning model consistently in the vocational learning.

1. Introduction

This research was conducted for the sake of quality improvement of an effective course in accordance with the demanded competences. The college curriculum that have developed and implemented is a competence-based. The core of the curriculum is to make students able to produce objects or projects correctly and appropriately. The main problem in this study was the students relied heavily on information from the lecturers as a single source. They were not accustomed to find other alternatives that might be used effectively and efficiently in learning. Consequently, the students were only able to duplicate the analog electronic circuits and were not yet able to find and to apply the analog electronic circuits for various applicative situations.

Learning analog electronics should use a student-centered learning approach, but in reality the approach is still teacher-centered. Therefore, in order to change the learning approach to be student-centered, it requires the existence of learning that provides focused and directed learning activities, such as project-based learning. The students tend to learn by remembering derivatives of formulas or equations without understanding the principles and procedures that exist in learning electronic circuits. This makes students perception on electronic circuits is difficult and boring, and they are unable to produce high performance [3][4]. Another view shows that the learning process in which unable to implement constructivist-learning theory is not able to encourage students to build their initial knowledge then students are less active in directly participating to the learning process. As a consequence, their learning outcomes are low.



Student-centered learning provides opportunities for students to be responsible for their learning activities [5]. The implications of student-centered learning activities can improve students' creativity to always learn and study their course materials so that learning outcomes increase in the field of electronic circuit systems [6]. One relevant learning model used to achieve the learning objectives and to support vocational skills was learning activities that enhance to produce products [1]. The chosen learning model might be a problem solving in the learning process of the Analog Electronics. Such problem solving was done by intervening the project-based learning model in the class.

Identification of the constraints listed above could be a prolonged problem if the solutions were not found. One that could be done was by conducting the research on the project-based Analog Electronics learning model intervention to the students of Electronic Engineering Education Department. Therefore, the main problems of the research were: (1) how do learning activities in the project learning of the students Electronic Engineering Education Department? (2) how is the effectiveness of project-based learning model on the learning outcomes of the Analog Electronics?

The aforementioned explanation above shows that there is a need for a student-centered learning model so that there is a knowledge sharing between students and teachers/lecturers in a relatively short time. Thus, students need to be given the opportunity to learn and to work together to develop effective learning principles and procedures. One learning model that is predicted to be able to improve the quality of the process and achievement of learning outcomes is a project-based learning model that focuses on student collaborative activities [7].

Supports for the project-based learning model shows that it is very useful for designing effective and potential learning that facilitates the ability to design systems in a project collaboratively [8], [9]. The project-based learning is practical and requires laboratory availability, such as the work on designing electronic circuits, designing mechanical systems that are used for controlling/regulating electronic circuits.

The project-based learning requires three main stages: (1) project planning, (2) project implementation, and (3) project evaluation [6],[10]). Project planning is the basis for conducting learning activities carried out by lecturers consisting of: (a) project selection, (b) project modification, and (c) project completion. Project selection is based on learning objectives that have been agreed between lecturers and students, taken from the project or system needed by the users/industries. If the project is large and long-term, lecturers and students must modify the strategy based on the syntax and the length of time of the course as well as pay attention to learning activities during the class [11], [12]. In general learning activities start from the preliminary activities, the core activities, and the final activities [13], [14].

This research was an effort to find the right learning strategy in vocational learning in the field of analog electronics aiming at: (1) describing the differences in the results between learning analog electronics using the project-based learning model and that with direct learning model (direct instruction) on the learning outcomes of analog electronics circuits; (2) describing the student learning activities in the project-based learning model in the analog electronic circuit course material; and (3) describing the student responses on the project-based learning [10], [15].

2. Method

The research stages in the project-based learning model in the Analog Electronics course consisted of: (1) project selection, (2) project completion stage planning, (3) activity schedule preparation, (4) completion of the project monitored by the lecturer, and (5) the report writing [7], [1].

This research used a mixed research design using quasi-experimental and descriptive design [16]. The population was the students of Electronic Engineering Education registered in the odd semester of 2016-2017 academic year. In this research, the sampling technique used was the homogeneity test toward the population of students who had programmed the Analog Electronics course. The students with odd student ID numbers were put in the experimental group while those with the even ID numbers were in the control group. The total students were 32 people for each class. The students were divided randomly into several groups consisting of 15-16 students for each. Each group was given the

freedom to design an electronic amplifier circuit along with the steps to be taken. For the trial phase, it was carried out in the fourth stage (activity monitoring). The questionnaire regarding the students' responses data that had been filled out by the students during the activities were collected after the learning was completed. While the data related to the learning activities were obtained from the observations, the learning outcome data used the results from a cognitive test contained 32 questions that had been validated. The affective data collection was based on the observations while the cognitive competence data were taken from post-test result. Interview and documentation were occupied in supporting the existing data. Last, the analytical method to test the hypothesis for cognitive competency was using the independent sample t-test with an alpha of 0.5% using SPSS Ver. 22.

3. Results and Discussion

The research results of the pre-test and post-test of the experimental group and the control group using the mean scores of the learning outcomes can be described as follows:

Table 1. The gained mean scores of pre-test and post-test results.

Research Groups	Pre-test	Post-test	Gained Scores
Experimental	42.05	71.08	38.70
Control	43.02	52.50	7.09

Based on Table 1, the mean score of the experimental group is higher than the control group's score. It means the learning outcomes of the project-based learning model intervention could improve the learning outcomes in the analog amplifier electronics course material (direct instruction). In other words, this quasi-experimental research on the project-based learning model with random sampling groups using cognitive achievement test (remembering, using, and finding) showed an increase in the good category. The application of project-based learning model was better than the direct learning.

In relation to the results of this research on activities that occurred in the learning process, the students got involved together in the learning but had not obtained excellent learning outcomes. This happened because the students were not familiar with the project-based learning model. Further observation results using direct observation sheets recorded that the students remained active when the learning took place, but then they felt hesitant when working on the post-test questions since they tended to expect answers from other friends who looked more active during learning. Based on the analysis results of the learning activities, the mean value for the experimental group on the second and the fourth meetings is as follows.

Table 2. Recapitulation of the mean values for learning activities

No.	Indicators of Activity	Experimental Group		Mean Score
		1	2	
1	Paying attention	82.37	79.43	80.90
2	Asking questions	87.32	84.20	85.76
3	Answering questions	73.20	82.31	77.76
4	Discussing	91.52	94.37	92.95
5	Note-taking	81.20	83.31	82.26
6	Doing the tasks	78.30	86.20	82.25
7	Observing	72.35	79.15	75.75
8	Initiating learning	72.50	79.35	75.93
9	Conscientious	84.55	87.68	86.12
10	Disciplined	91.20	90.15	90.68
11	Responsible	79.82	76.77	78.30
	Total	894.33	922.92	-

Mean Score	81.30	83.90	82.60
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The learning activeness of the experimental group with the project-based learning model intervention was in the active category. The experimental group discussion activity was categorized as very high and their observation activity was also categorized as good. When doing the discussion, the experimental group had more time to work together and to remind each other, and no one worked individually as well. In the meantime, observations of the student responses on learning were carried out during the learning process. Analysis results of the questionnaire of the experimental group's responses during the project-based learning were implemented and the results can be described in the following table.

Table 3. Recapitulation of domains of learning outcome

No.	Domain	Responses	Number of Activity		Mean Score
			I	II	
1	Remember	1. Being able to read the trial steps based on the electronic circuit amplifier systems.	82	80	81
		2. Giving structured feedback on the course material based on simple presentation order.	80	83	81.5
2	Use	1. Being able to design the electronics circuit amplifier system trials.	79	81	80
		2. Reinforcing the course material presented and the summary for the ease of learning.	79	82	80.5
3	Find out	1. Finding out the learning materials related to the electronic circuit power amplifier based on the learning objectives and the learning model used.	90	92	91
		2. Finding out the power amplifier circuit for radio signal frequency above 20 KHz.	77	82	79.5
4	Analyze	1. Analyzing the power amplification on the audio circuit and the strategies of learning material summary presented.	79	82	80.5
		2. Doing presentation with new assignments and advanced analysis of power amplifier circuits.	82	79	80.5
5	Synthesize	1. Giving feedback on the learning material based on the order of presentation and comparison of circuit analysis.	74	76	78
		2. Comparing the results of the observations and the analysis results of the amplifier circuit trials.	72	76	74
Mean of Learning Outcome Achievement					80.45

Based on Table 3, the achievement of learning outcomes obtained was in the very good category. These results indicated that the intervention of the project-based learning model that consistently used the steps of the project-based learning model provided excellent learning outcomes when compared to the conventional learning strategies (lectures, discussions, and structured assignments). These results are consistent with some previous studies results that found effective learning must be able to involve students in problem solving activities and provide learning opportunities for students to work independently and construct their own realistic product [17], [18]. This is due to the project-based learning model establishes student activities to produce products by applying skills of researching, analyzing, creating, and presenting their products of learning based on real experiences. The results of this re-

search are in line with the previous research [1]. Such products are the results of the projects in the forms of a design, scheme, writing, artwork, technology/craft, and values.

This approach also allows students to work together independently or in groups in constructing real products. This principle supports the achievement of vocational competences as prospective teachers at high schools because the focus of project-based learning lies in activities to produce real products by applying the skills of research, e.g., analyzing, creating and presenting products based on real experiences in the class [7], [8]. The project-based learning is an activity that involves students in a complex way as it requires strategic stages with a long duration of learning activities, focuses on projects or tangible results, and must reflect three basic elements, namely: (1) project planning, (2) project implementation, and (3) project evaluation [10], [15]. Therefore, the project-based learning as one of the learning strategies can be used to achieve the competence of knowledge and skills in vocational learning programs.

To provide reinforcement on the results of the research, the project-based learning activities that must be accounted for are: *first*, lecturer must demonstrate and explain the main requirements of project materials and learning objectives to students that makes students have knowledge about the project. *Second*, lecturer explains the organization and arrangement of activities so that the implementation is in order and smooth based on group assignments and method of assessment. *Third*, lecturer should observe the activities of each group, participate in discussions, direct students to analyze, think, explore, and solve problems, as well as develop comprehensive vocational skills to unify/integrate the project elements in coherence [10]. *Fourth*, lecturer explains the basic principles of method and recommends that students to complete the project in an integrative process. *Fifth*, lecturer conducts a two-step evaluation: process evaluation and summative evaluation. Each student conducts a self-evaluation based on the independent tasks to complete the project, then lecturer evaluates the attitudes and behavior of each individual and gives an assessment [20], [21]. Summative evaluation is an evaluation of the results of project. The group leaders show the results of the project and assess the results of the project, show the advantages of project implementation, then the other groups ask questions and evaluate the weaknesses of the project result. At the end of the activities, lecturer provides an assessment by combining self-evaluation and joint evaluation. Lecturer give reinforcement to the groups or individuals who get very good results and provides opportunities for those who have not succeeded well also convinces them that they can complete the task well.

Student activities in the project-based learning produce products by applying the skills of researching, analyzing, creating, and presenting the products of learning that fit the real learning experiences. The product is the result of a project in the forms of design, scheme, technology, and craft. This model intervention allows students to work both independently and in groups to construct real products. Therefore, the results of this research are applicable to groups of students who have a lot of learning experiences or in the final semester in a study program.

4. Conclusions and Suggestions

Based on the results and discussion of the research that have been presented, the project-based learning is an instructional model that involves all students directly in the learning process through research activities to carry out and complete a project.

1. The project-based learning is considered good to provide learning activities, especially the interactions of individuals and groups in completing a project or tangible object in the vocational learning process.
2. The project-based learning uses projects (activities) as the core of learning. In such activities, students explore, assess, interpret, and synthesize information to obtain various achievements of learning outcomes (knowledge, skills, and attitudes). Nevertheless, in this research the learning outcome achievement was focused on the cognitive test or knowledge that was related to the stages of: (1) project selection, (2) project completion stage planning, (3) schedule preparation, (4) completion of projects monitored by lecturer, and (5) preparing reports.

3. The learning activities, especially related to the power amplifier, has a higher contribution to the explanation of the learning materials, examples of the learning materials, and the provision of exercises for the competencies of remembering, using, and finding out concepts, principles, and procedure of learning materials presented in the vocational learning.
4. To those who are interested in the results of this project-based learning model research should pay attention to the learning stages consistently in order for the betterment of learning activities and learning outcomes and having a better impact on the competence of the study fields as well as on the professional competence of prospective vocational teachers in the Electronic Engineering Education Department.

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