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The Effect of Problem-Solving Skills on Learning Outcomes of Analog Electronics Course

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Abstract— *This study is based on previous study in 2022 that showed the problem-solving skills of students enrolled in Analog Electronics course does not meet the expectation. This study aims to determine the improvement in problem-solving skills of analog electronic as a result of the application of problem-based learning (PBL) method. The research method is quasi-experimental with two learning strategies: problem-based learning and conventional learning. The research population is all students of the Electronics Engineering Education Study Program who had programmed the Analog Electronics course. Purposive sampling is employed in selecting 32 (thirty-two) students as research sample. The research instrument used is a test of analog electronics problem-solving skills. The results show that (1) the improvement in problem-solving skills of students who are taught with problem-based learning method in experimental group (27.78) higher than students who are taught with conventional learning in control group (17.28), and (2) the mistakes made by students when taking tests related to analog electronics are mistake due to not reading the test carefully, mistake in transforming information, mistake in processing skills, and misunderstanding questions.*

Keywords— *Analog electronics course, problem solving skills.*

I. INTRODUCTION

The Analog Electronics course discuss aspects of continuous electrical signals, while the components used are generally called discrete components that control the main circuit to increase vocational competence and thinking ability to solve electronic circuit problems. It is a set of component symbols that are placed in a series, parallel and mixed circuit system to control voltage and current quantities and in the form of a symbolic language that functions practically (Tokheim, 1990). Therefore, the Analog Electronics is an essential and a compulsory course for students majoring Electronics Engineering Education. It shows that the quantitative relationship between the circuit is intended to facilitate ways of thinking. In learning process, students' abilities are enhanced through the provision of learning problems, so they can improve their various competencies, especially vocational competencies. This is in line with research by Dahar (2011) which states that the ability to solve problems is the main goal of the learning process.

Based on the results of previous research, the learning outcome of students majoring Electronics Engineering Education Study Program in learning electronic circuit analysis is still relatively low, especially in terms of the ability to solve circuit analysis problems. From the data obtained, 72.16% of students still have relatively poor problem-solving skills. This is due to several things, including students' lack of motivation in learning analog electronics circuits, the learning process which still relies on the lecturer's role as a provider of all information on teaching materials, and insufficient learning facilities.

Problem is a discrepancy between real conditions and expectations. From the aspect of the curriculum, problem-solving ability is one of the goals in learning analog electronics circuits in the electronics engineering education study program, namely training ways of thinking and reasoning in drawing conclusions, developing problem-solving skills, and developing the ability to convey information or communicate ideas through presentation, written, circuit drawings, graphs, maps, diagrams (Ministry of National Education, 2006). In line with the objectives of learning analog electronics in the Higher Education curriculum (2022), students must have problem-solving skills which include the ability to understand problems, design and design electronic control circuits, complete models and interpret solutions obtained.

The ability to solve problems is very important for every student to have because: (a) problem-solving is the main achievement of analog electronics learning, (b) problem-solving which includes methods, procedures and strategies is the core and main process in the curriculum of Electronics Engineering Education study program, and (c) problem-solving is a basic ability in learning analog electronic circuits (Sugiyono, 2022; Kiong, et.al, 2022). In addition, Ruseffendi (1991) describes that the ability to solve problems is very important in the analysis of electronic circuits, not only for those who will later study design, but also for those who will apply them in the field of industrial electronic circuits.

Students' ability to solve problems in analog electronic circuits needs to be supported with appropriate learning strategies so that learning objectives can be achieved. Wahyudin (2008) states that one important aspect of lesson planning is based on the ability of lecturers to anticipate needs and teaching materials or problem-solving models that can help students achieve learning goals. In accordance with research by Sagala (2011), lecturers must have strategy that can make students easier to master the analog electronics teaching materials. In addition, lecturers must know the difficulties experienced by students in learning analog electronic circuits so that appropriate solutions can be provided.

One of the methods that is thought to improve students' ability to solve analog electronics circuit problems is Problem-Based Learning (PBL). PBL is a method that uses real world

problems as a context for students to learn about higher order thinking (HOTS) and problem-solving skills as well as to acquire essential knowledge and concepts from learning materials. Arends (2008) describes that problem-based learning is designed to help students develop their thinking skills, problem-solving skills, and intellectual skills.

Based on the description above, the formulation of the research problem in this study in general is "can Problem-Based Learning improve the problem-solving skills of Analog Electronics circuits for students in Electronics Engineering Education study program?". The formulation of the research problem above is made up of sub-problems as follows:

1. Do students' problem-solving ability who receive Problem-Based Learning method is better than students who receive conventional learning?
2. What mistakes do students make when working on Analog Electronics questions?

A. *Problem Solving Skills in Analog Electronics Course*

Problem solving is a process to overcome the difficulties faced by students to achieve predetermined learning objectives. In Analog Electronics course, students must have problem-solving skills to solve problem-based questions. Problem solving is a thinking process to solve questions to achieve learning objectives. It is an activity that prioritizes the importance of procedures, strategic steps taken by students in solving problems and finally being able to find answers to questions not only in the answers themselves (Sumarmo 2000; Bariyyah, 2021).

Problem solving skills are abilities based on the process of identifying problems, finding alternative solutions, and implementing the best solutions in relatively new situations (Araiza-Alba et al., 2021; Graesser et al., 2018; Pinter & Cisar, 2018). Meanwhile, according to Özreçberoğlu & Çağanağa, (2018) stated that problem solving skills are the ability to solve all problems and make decisions. Dörner & Funke, (2017) define problem solving skills as the ability to define problems, determine the causes of problems, determine priorities, select various options for solutions and implement these solutions. Based on the opinions of some of these experts, it can be defined that problem solving skills are the ability to classify problems, discover numerous alternative recommendations in solving problems faced.

Polya (Ruseffendi, 1991) describes that to solve a problem for students, four steps are needed, such as:

1. *Understand the problem*

The activities that can be carried out at this step are what is known (data), what is not known (asked), whether the information is sufficient, what conditions must be met, restating the original problem in a more operational form.

2. *Plan the solution*

Activities that can be carried out at this step are trying to find or remember problems that have been solved that are similar to the problem to be solved, looking for patterns or rules, compiling settlement procedures (making conjectures).

3. *Solve the problem according to plan*

Activities that can be carried out in this step are carrying out the procedures that were made in the previous step to get a solution.

4. *Re-examine the procedure and results of settlement*

Activities that can be carried out in this step are analysing and evaluating whether the procedures applied, and the results obtained are correct, or whether the procedures can be generalized.

The results of identifying problem solving skills indicators of Analog Electronics course in this study are: (1) understanding the problem and planning problem solving; (2) create a process of solving a problem; and (3) explaining or interpreting the results according to the original problem, as well as checking the correctness of the results or answers.

B. *Problem-based Learning (PBL)*

Problem-based Learning (PBL) is a learning method for students to think critically, analytically, systematically, and logically to find alternative solutions to problems through the exploration of empirical data to promote scientific attitudes. It was first introduced in the early 1970s as a mean to find a solution in diagnosis by making questions according to the existing situation. Duch (2001) defines that problem-based learning is a learning approach that has the characteristics of using real problems as a context for students to learn critical thinking, problem-solving skills, and gain knowledge about the essence of the course.

Referring to Duch's definition, problem-based learning is learning that demands students' mental activity optimally in learning critical thinking, problem-solving skills, and acquiring knowledge about the essence of subject matter in understanding a concept, principle, and students' analog electronics skills in the form of real-structure or open-ended through stimulus.

According to Forgarty (in Rusman, 2012) the steps that students will go through in PBL process are as follows:

1. Find a problem;
2. Define the problem;
3. Collect facts;
4. Develop a hypothesis;
5. Carry out investigations;
6. Improve the problems that have been defined;
7. Conclude alternative solutions collaboratively; and
8. Test the results of problem-solving solutions.

Problem-based learning has ten characteristics as stated by Amir (2009), such as (1) problems become a starting point in teaching and learning process, (2) the problems raised are problems that exist in the real world that are not structured, (3) problems require multiple perspectives, (4) problems challenge students' knowledge of attitudes and competencies which then require identification of learning needs and new areas of learning, (5) learning self-direction becomes the main thing, (6) utilization of various sources of knowledge and evaluation of sources of information is an essential process in teaching and learning process, (7) learning is collaborative, communication, cooperative, (8) development of inquiry and problem solving skills is as important as mastery of content knowledge for finding solutions to a problem, (9) synthesis and integration of a learning process, (10) teaching and learning process involve review and evaluation.

Based on the description above, the stages of Problem-based Learning (PBL) activities are shown in Table I.

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TABLE I. Stages, indicators, and activities in carry out PBL

Stages	Indicators	Activities
1	Student Orientation on Problems.	Explaining learning objectives, materials needed, motivating students to be involved in problem solving.
2	Organize students to study	Help students to define and to classify learning tasks related to predetermined problems.
3	Guide individual experiences or groups of students.	Encourage students to collect information, carry out experiments, get explanations and solution.
4	Develop and present student work.	Motivate students to collaborate with peers by distributing parts in the assignment and assist students to prepare their reports
6	Analyze and evaluate the problem-solving process.	Help students to reflect and evaluate their investigations and the process used.

Based on Table I, lecturers' activities begin the teaching and learning process by explaining the learning objectives, describing teaching materials, and motivating students to be involved in solving learning problems.

Meanwhile, students are guided to make plans, strategies, and observations that lead to problem solving as to build their own knowledge through real experience. Then, students identify problems by looking for things that are known, what is asked, and looking for ways that are suitable for solving problems by investigating and solving problems. Students use a lot of skills that can be seen as motivation to solve real problems and lecturers show appreciation, so students are joyfully collaborate.

II. Research Methods

The research used a quasi-experimental research design using a non-equivalent control group design with the formula based on Ruseffendi (2005):

$$\begin{array}{ccc} O & X & O \\ \hline O & & O \end{array}$$

Note:
O: Test of analog electronics problems
X: Problem-based learning

Population of the study is all students of the Electronics Engineering Education study program who had programmed the analog electronics course. Purposive sampling technique was used to get 32 students of the Electronic Engineering Education Study Program in Faculty of Engineering UNM as participants in September 2021.

III. Results and Discussion

The results of the data obtained from the implementation of the pretest and posttest tests, with N-Gain were processed using SPSS 2022 are presented in the following table:

TABLE II. Descriptive statistics of students' problem-solving skills

Test	Experimental Group			Controlled Group		
	N	X	S	N	X	S
Pre-test	32	44.03	12.31	32	39.31	12.760
Post-test	32	71.81	14.545	32	56.59	12.336
N-Gain	32	0.52	0.20	32	0.38	0.18
Maximum Score= 100						

Based on Table II, there is a significant increase in students' problem-solving skills of analog electronics after receiving treatment. Students in the experimental group obtained a higher than the controlled group. The mean increase of the experimental group from post-test (71.81) to pre-test (44.03) is 27.78. This result is an increase in change. While the mean increase for the controlled group from post-test (56.59) to pre-test (39.31) is 17.28. These results indicate that students' skills in solving the problem of analog electronics course in the experimental group are better than the controlled group. Furthermore, based on the N-gain, the experimental group is higher than the controlled group, although both are interpreted in the moderate category.

The results of normality test using the SPSS 2020 software on the ability to solve analog electronics problems by students of the Electronics Engineering Education Study Program is shown in Table III.

TABLE III. Results of normality test of pretest and posttest on students' skills in solving problems of analog electronics course

Result	Group	*Shapiro Wilk*		
		Statistic	*Df*	*Pig*
Pre-test	Experimental	0.927	32	0.018
	Controlled	0.835	32	0.000
N-gain	Experimental	0.873	32	0.001
	Controlled	0.965	32	0.413

Based on the data in Table III, the pre-test results for the experimental group and controlled group have sig <0.05, so for both H_o is rejected, meaning that the pre-test scores for the analog electronics problem-solving skills of the experimental group and controlled group are not normally distributed. The N-gain results for the experimental group have sig <0.05, then H_o is rejected, meaning that the N-gain scores for the analog electronics problem-solving skills of the experimental group are not normally distributed. Because the controlled group has sig > 0.05, then H_o is accepted, meaning that the N-gain score for the analog electronics problem-solving skills of the controlled group is normally distributed. Since the pre-test scores and the N-gain of the two groups were not normally distributed, the hypothesis testing used a nonparametric test, namely the Mann Whitney-U test.

TABLE IV. Result of the pretest mean similarity test of students' skills in solving problems of analog electronics course

Statistics	Score	Result
Mann Whitney-U	584.000	**H_o accepted**
Z	-0.730	
Asymp.Sig. (2-tailed)	0.465	

Based on the data in Table IV, the value of sig is 0.465. Since the sig value > 0.05 then Ho is accepted. It means that there is no difference in the mean pre-test scores of analog electronics problem-solving skills in the experimental group and the controlled group.

TABLE V. Result of T-test on N-gain of students' skills in solving problems of analog electronics course

Statistics	Score	Result
Mann Whitney-U	317.000	**H_o rejected**
Z	-3.714	
Asymp.Sig. (2-tailed)	0.000	

Based on Table V, the value of sig is 0.000. Because this study uses a one-sided test, the sig value becomes 0.000 so that sig <0.05 means that Ho is rejected. This means that the increase in analog electronics problem-solving skills of students who receive PBL is better than students who receive conventional learning. The results of the analysis in general can be obtained empirically that there are differences in the ability to solve analog electronics problems between students who are taught using problem-based learning method than conventional learning strategies in the Electronics Engineering Education Study Program.

In terms of mistakes made by students when working on an Analog Electronics test, some of them are in-line with the study conducted by Nurkaeti (2018). Some common mistakes found in this study are:

1. Errors due to carelessness or inaccuracy. Students make mistakes because they are not careful in understanding concepts, many of them are wrong in writing the formula of the constant equation for analog electronic circuits. It should be based on a picture of an analog electronics circuit made by a student, the formula used is series and combination equations. As seen from the results of students' work, it is clear that the mistakes are due to their lack of mastery of circuit techniques and the polarity of passive electronic components.
2. Errors in transforming the information in the problem. There was a student error in understanding about electronic circuits. students are correct in writing the concepts and principles about series parallel circuits and combinations of analog electronic circuits, but students have not been able to capture the information contained in the problem. students are wrong in writing a series circuit in an amplifier circuit which should be a mixed circuit added first to the length of the other part of the search using the first and second law of Kirchhoff's.
3. Students make mistakes in doing multiplication calculations, which would cause wrong answers. This is caused because students might in a hurry in doing the calculations.
4. Students made a mistake in understanding the questions, namely determining the calculation of a parallel circuit with two resistors. Students assume that the circuit is parallel so that it immediately determines the total amount of resistance.

IV. Conclusions and Suggestions

1. The improvement of students' problem-solving skills who are taught with PBL is better than students who are taught with conventional learning.
2. The characteristics of mistakes made by students become empirical data for lecturers to improve the quality of feedback in lectures.
3. The mistakes made by students when working on questions related to analog electronics problem-solving abilities are mistakes due to not carefully looking at analog electronic circuit systems, errors in transforming information, process skill errors, and errors in understanding the characteristics of analog electronic circuits in each question item.
4. The empirical data of this research can be used as a basis for making analog electronics circuit questions based on learning outcomes.

Based on the research conclusions above, some suggestions are proposed as follows:

1. Problem-based learning can be used as learning in the electronics engineering education study program and Vocational High Schools (SMK) to improve analog electronics problem-solving competencies.
2. It is expected that there will be further research to determine the effectiveness of problem-based learning at the level of knowledge mastery of analog electronics circuits in SMK.
3. This study only studied the overall improvement of analog electronics problem-solving skills. Therefore, it is hoped that further research can examine the increase in problem solving skills based on students' initial abilities in high, medium, and low categories.
4. In every lecture, the lecturers should always evaluate and return the results of students' work, especially if there are errors in concepts/ principles so that improvements can be made in the next lecture.

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