

Implementation of Learning Together Method with Ltspice Simulation to Enhance Student's Comprehension in Electric Circuits Course

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Abstract—Electric Circuits is one of mandatory courses in electrical engineering. This course consists of basic electronic components, modeling concept and circuit analysis in direct current (DC) or alternating current (AC) which are fundamental for varies advance courses. However, this course gives a significant contribution to student's failure at every term. The data, from last term, show that 16.02% of 256 students got D, E and T (DET) grade. That is exceed 15%, a standard set by Telkom University. This research proposes a fusion method between Learning Together method (LT) and software (LTSPICE) simulation. LT method's aim is to leveling knowledge for each student meanwhile software simulation's is to give a better understanding for students and verify their work. The purpose of this research is to find a suitable learning method which can reduce DET index and to increase student's achievement in electric circuits course at Telkom University. This research is an action research which is designed in two cycles. Each cycle consists of four steps: Planning, Acting, Observing and Reflecting. The research data are obtained from observation form, assignment and exam results (pretest and posttest). These results showed that the proposed method can increase student's achievement about 3% in final exam compared with a mid-term exam and it successfully decreased DET index about 5% compared to previous term results.

Keywords—*learning together technique, action research, engineering education*

I. INTRODUCTION

One of the mandatory courses in electrical engineering is Electric Circuit. In this course, the students will learn about basic components and circuits concept in electronics and how to analyze them. These knowledges will be used in varies advance courses in electrical engineering. However, this course gives a significant contribution for student's failure in every term. It is a big challenge for lecturers to encourage students to have a good knowledge in electric circuits as fundamental skill in their profession.

TABLE I. LIST OF SCORES ELECTRIC CIRCUIT COURSE AT 2016-2017.

Grade	Number of Students	Percentage
A	37	14.45%
AB	23	8.98%
B	34	13.28%
BC	76	29.69%
C	45	17.58%
D	25	9.77%
E	16	6.25%
T	0	0%

From Table I, the data show that 16.02% of 256 students got D, E and T (DET) grade which exceed 15%, a standard that was set by Telkom University.

The purpose of this research is to find a suitable learning method that can solve the problem and to increase Telkom University student's achievement in the electric circuits course. Hopefully, this research also can give positive contributions in engineering education, and it can be adopted in the other suitable courses.

The rest of this paper is organized as follow: Section II describes the fundamental concepts used this work. Section III presents proposed research method. Section IV presents the obtained results and following by discussion. Finally, Section V concludes this work.

II. RUDIMENTARY

Several methods were adopted and developed to improve student knowledge in engineering-education. A research done by Savanne-Ranne [1] has been discussed about an alternative approach in teaching for electrical engineering courses. It proposed and interactive teaching method to teach RF Circuits course. Another research done by Berry [2] suggested online course in electric circuits class which improve the efficiency without decreasing level of learning.

Learning Together (LT) method for science and language course was explicitly proposed in a research done by Gokkurt[3] and Orprayoon[4]. The results of these showed that LT methods can increase student's achievement efficiently in challenging courses. Software simulation was used to enhance student's comprehension in Electric Circuit course by Itagi[5] and Salunke[6] and it has been successfully increased student's understanding in the class. Based on those references and our experiences in Electric Circuits teaching for about 14 years, a combination of LT method and software simulation will be suitable to be implemented in our class. LT method will be effective in enhancing and leveling student's knowledge meanwhile software simulation will give a good visualization of circuits result, verify their works and to trace mistakes.

A. Cooperative Learning

Cooperative Learning is a small group of learners, working together as a team, to solve a problem, complete a task or accomplish a common goal [7]. There are many different cooperative learning techniques [5]. These are:

- a. Student Teams Achievement Divisions (STAD)
- b. Number Heads Together (NHT)
- c. Jigsaw
- d. Team Games Tournament (TGT)
- e. Assisted Individualization (AI)
- f. Learning Together (LT)
- g. Group Investigation (GI)

Learning together method is a technique that was developed by D.W. Johnson and R.T. Johnson. In this technique, a class or students would be divided into some small heterogeneous groups. Every member can share their knowledges and work together to finish the group assessment. Group achievement would be count as individual achievement [5]. This method allows member that has an excellent capability to share his knowledges and teach other members about the materials. It can stimulate every member to have equal comprehension about the topics.

B. LTspice Software

The LTspice is high performances SPICE (Simulation Program with Integrated Circuit Emphasis) simulator and it can be used for digital or analog circuit simulation (see Figure 1).

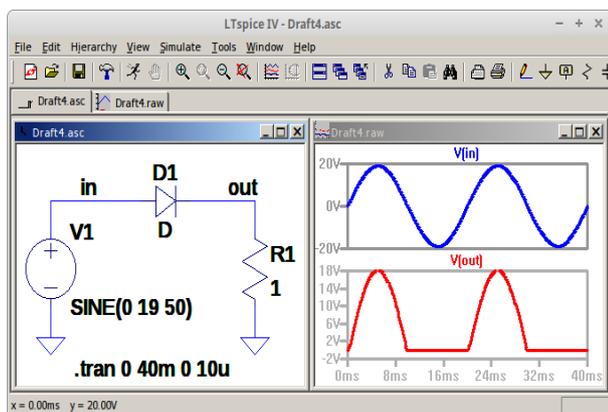


Fig. 1. LTspice Illustration

This software can be used to check various kind of circuit configuration and predict the characteristic of

electronics component, such as IC, Op-amp, transistor, resistor, capacitor even the elements are operated at high frequency. This software can show the waveform of dynamically measured parameters. Same as the other SPICE program, LTspice is easy to use. This software is open source, free for use. Consequently, it can only be used to simulate several components that are produced by Linear Technology.

III. PROPOSED METHOD

A. Research Design

The method of this research is action research. This method was introduced by Kemmis and Taggart that is developed from Kurt Lewin model [8] (see Figure 2). There are four critical components of this method that are:

- 1) Planning
This phase consists of making research proposal and preparing learning set such as modules of materials, instrumentations and scoring rubrics.
- 2) Acting
This phase consists of everything that was written in the learning plan.
- 3) Observing
This phase is running at the same time with an acting stage. This phase consists of observing how the cycle is running and gathering research data.
- 4) Reflecting
This phase consists of analyzing the research data, generating temporary conclusion and arranging some improvements for the next cycle.

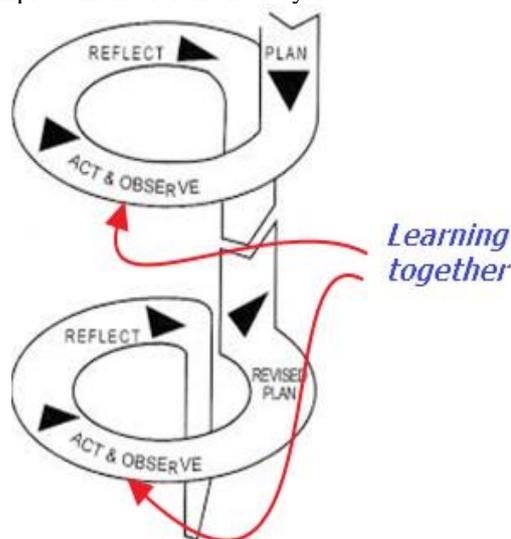


Fig. 2. Kemmis and Taggart Model [9]

Figure 2 above shows that all phases of every cycle are connected circularly. It means that, after reflection phase finish, the next phase is start from the first phase on the next cycle, if it is necessary. There is pretest and posttest in the beginning and the end of every cycle, and it is compared to know the effects of the implementation in every period.

Every research data that were gathered in the observation phase is classified and assessed based on determined scoring rubrics. This research uses analytic rubrics to generate a score for non-test instruments

(observation form, questionnaire, and members work appraisal form). The main reason is, the instrument's subjects are quite simple to assess. Individual assessments, group assessments, mid-term exam and final exam are evaluated based on a score of the correct steps in their work. Because of the evaluations is exact, the count of every level can be determined precisely. Each instrument has a different contribution to the total score of a student, based on the research's purpose.

B. Realization

The research consists of two cycles. The first cycle was conducted at the first week of November 2017 and the second cycle was done in first week of December 2017. First cycle's topic is fundamental method circuits analyzation in DC circuit and the second cycle's theme is circuits analyze theorem in AC circuit. The course materials of these cycles are quite similar. There are four steps that were done in every step:

1) Planning

This step was done before every cycle is running. In the first cycle, this step consists of making research proposal and preparing learning set such as modules of materials, observing instrumentations, assessment's scenario and scoring rubrics. In the second cycle, this step was updating next cycle's scenario based on reflecting step's results in the previous cycle.

2) Acting

This step was quite similar in both of cycles. In this step, the lecturers give materials based on learning plan, dividing the class into ten heterogenous groups, provide time and space to do group discussion and give weekly assessments. Based on previous cycle's result, in the second cycle, the frequency of group discussion was increased to rise the research's results.

3) Observing

Observation step was conducted in the end of every cycle. The purpose of this step is for collecting research data. This step consists of 4 activities. First, lecturers explain the rules of the activity and arranging the group position. Second, lecturers give module that is consist of materials and exercises that can be discussed in a group for 60 minutes. Third, students do the assessments. The assessments consist of individual and groups assessments. Students doing group assessment in 45 minutes. After that, students doing individual assessment in 45 minutes. The last activities are filling questionnaire form, filling work appraisal from and collect them to observers. Lecturers observe the students during the activities and write down the result into observer form. Basically, observation step was quite similar in both of cycles. There is an update in collecting data questionnaire and work appraisal from manual form to web based to increase efficiency.

4) Reflecting

Reflecting step is divided into two activities. First, collect and analysis data to get temporary (or final) conclusion.

Second, compose some improvements for next cycle (or research) based on previous results.

C. Samples

Samples of this research are 83, second grade Telkom University, students that are divided into two classes. These classes are part of eight classes that conduct Electric Circuits course in this term. The observers consist of two Electric Circuits lecturers of these classes. So, they know the problems, capabilities of their students and how to treat their students in the class. These classes also have quite similar mean knowledge achievement. So, the observers can compare the results between two classes in the same input treatments.

D. Instrumentation

Data of this research are gathered with two kinds of research instrumentations. There are:

1) Non-Test Instrumentation

a) Observer Form

This form is filled by the observers based on their observation results. There are ten aspects of every group that must be observed during the activities such as, readiness and spirit to follow the class, participation in group discussion, communication skill, etc.

b) Questionnaire

This form is filled by the students and designed to obtain student's response about the proposed method. The seven aspects in this form such as, contribution of the learning method to student's comprehension, effectivity of group discussion to enhance student's comprehension, etc.

c) Work Appraisal From

This form is filled by the student to give appraisal to the other member of their own group based on their contributions. The appraisal aspects in this form consist of teamwork, appreciation of other member's opinion, objectivity, the way of thinking and politeness.

2) Test Instrumentation

a) Pretest

Pretest score is generated from quiz result. Quiz was conducted in the beginning of every cycle. The quiz consists of two simple essay questions that are suitable with research's topics.

b) Posttest

Posttest score is generated from the combination of individual and group assessment results. Group assessment consists of two essay questions that could be done in a group. Individual assessment consists of one essay question that could be done individually.

c) *Mid Term Exam*

d) *Final Exam*

E. Data Analysis

The scoring rubrics for non-test instruments is analytic rubrics. It can be used to obtain the grading index for every observed aspect. Higher critical index means better result. Observer form would show how the implementation was running from observer’s view. It would be compared with work appraisal form’s results to get the valid condition. Questionnaire form contains comments and feedbacks from the students. It can be used to make some improvements in the next cycle. A pretest is an individual quiz that is conducted at the beginning of every period. Two different ways can be chosen by the students to do this quiz, manually and simulation. Total scores are obtained by accumulating all of points that was determined in every right step. Posttest is conducted at the end of the cycle. It consists of individual and group assessment. The students must do both assessments manually and in a simulation. Total scores in every evaluation can be obtained by accumulating a total score of manual and simulation work with comparison 60:40. Due to the real exams are done manually, simulation is just a tool to help the students understand the materials, the percentage of manual work is higher than simulation. Individual assessment result would be compared with an average of group assessment result to know the correlation of group’s comprehension and the comprehension of every member.

IV. RESULT AND DISCUSSION

Observation and data collection process were successfully conducted. On the second cycle, there was an improvement on data collection method especially on the questionnaire and work appraisal form. It was changed from a manual form into an online form to make these processes more efficient. The response of students about this method is very positive. The result of the questioners of the second cycle would be presented in the Figure 3.

The survey consists of seven aspects that can be used to know the contribution and effectiveness of the proposed method for increasing student’s comprehension. That results show that the students have a remarkable enthusiasm and they felt that the technique can help to improve their understanding efficiently. The increment of every aspect was about 4% on cycle 2. It means that motivation of the students to use this method were increased and the students have been realized the importance of software simulation to verify their work.

The remaining section wants to discuss and analyze student assessment’s results. All of materials are generated from credible books that were mentioned in the references [10] and [11]. The assessment’s standard has been adjusted to the standard of world class university that can be accessed in <http://ocw.mit.edu>. That link provides an example of electrical circuit subject’s final exam in MIT. It can be a valid reference to make some qualified questions that can determine the comprehension of students about the topics.

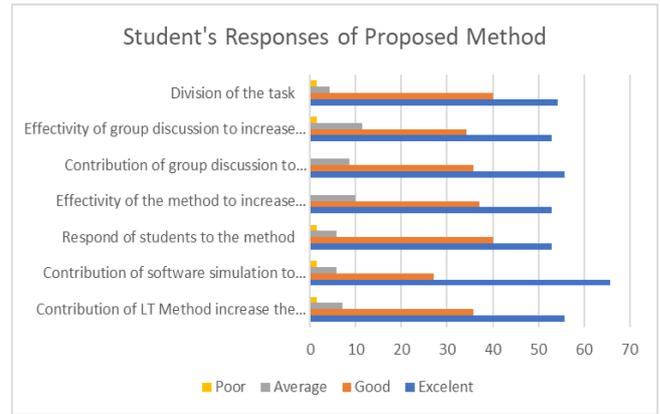


Fig. 3. The effect of questionnaires in the second cycle

A. Comparison of Achievement between Two Cycles

The results of posttest and pretest are presented in Table 2. That Table II shows the average score of pretest and posttest for every cycle.

TABLE II. COMPARISON OF ACHIEVEMENT BETWEEN PRETEST AND POSTTEST

Cycle	Pretest	Posttest	
		Group	Individual
Cycle 1	57.75	69.65	-
Cycle 2	55.88	56.67	64.6

In the first cycle, posttest scores are obtained for an average rating of group assignment. As shown in the Table 2, the method is successfully increasing the student's achievement about 11.9 points or about 20% in the posttest. In the second cycle, there is an individual assignment that has been given after group assignment finish. The purpose of this improvement is to know the correlation between a group and individual comprehensions. There is an improvement, from pretest result, 4.83 points or about 8.6%, compared with the average of a group and individual assessments, in the posttest.

Objectively, group assessment’s problems are more difficult than individual evaluations to encourage every group to discuss the issues. The result shows that group’s average result is lower than individual assessment's outcome. It means that the discussion process of every group was not running well. It would be an essential note in the future implementations.

Since the research materials are quite similar with other elements in mid-term exam, the effect of the proposed method also can be obtained from the comparison of the result between two points that have related topic in a mid-term and final exam (see Table III).

TABLE III. COMPARISON OF RESEARCH MATERIAL’S POINT SCORES ON THE EXAMS.

Mid-term Exam	Final Exam	Increase ment
47.78	49.26	3%

That results can show that the proposed method was successfully increasing student's comprehensions of the related topics.

B. The Comparison of Achievement between Two Consecutive Terms

The comparison of student achievements in the previous term (2016/2017) and present term (2017/2018) are presented in Table IV.

TABLE IV. STUDENT'S ACHIEVEMENT FOR ELECTRIC CIRCUITS COURSE IN TWO CONSECUTIVE TERMS

Index	2016-2017		2017-2018	
	Σ	%	Σ	%
A	25	33%	12	17%
AB	13	17%	7	10%
B	6	8%	15	21%
BC	6	8%	6	8%
C	9	12%	20	28%
D	8	11%	9	13%
E	8	11%	3	4%
T	0	0%	0	0%
Total	75	100%	72	100%

The results show that the purposed method can successfully reduce DET index of the class about 5% compared with the previous term. It means that if the method is implemented in all the classes, it will give a good possibility to reduce the total of DET index in this course less than the university's standard.

All of research's components such as instrumentation, scoring rubrics, modules of materials and research data had been completely uploaded into cloud storage.

V. CONCLUSION AND SUGGESTION

The research was conducted in two cycles. The first cycle was done in the first week of November and second cycle was done in the first week of December. All research's steps were successfully conducted. The were some improvements in the second cycle to make the research process more efficient. Results of this research showed that the proposed method efficiently increased student's comprehension in Electric Circuits course. According to student achievement index, if the method is implemented in all of the classes, it would give a good possibility to reduce the DET index of this course under the university's standard.

Suggestion for the future implementation is this method can be implemented separately based on student's problem and condition of the class to reduce the complexity.

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