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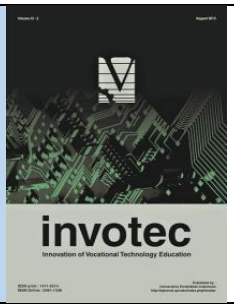

The Effectiveness of Problem-Based Learning Based on the Learning Management System on Critical Thinking Skills of Electronics Course Students

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ABSTRACT

This study aims to apply problem-based learning (PBL) by utilizing the Center for e-Learning and Open Education (CELOE) Learning Management System (LMS) and analyze the effectiveness of the implementation of PBL on the LMS CELOE media in improving students' critical thinking & problem-solving skills in the Electronics course. The Classroom Action Research Method (CAR) applies the research model initiated by Kemmis and Mc Taggart. Based on the observation results, LMS-based Project Based Learning is able to improve students' critical thinking and problem-solving abilities in the Electronics course. This statement can be confirmed from the results of repeated observations, namely the first and second cycles provide an increase in the post-test scores compared to the pretest scores. The level of effectiveness of the PBL method for Electronics courses in LMS in an effort to improve critical thinking, reached a value of 78% or can be said to be effective. In addition, the existence of discussion forums makes students active in communicating during the problem-solving process.

1. Introduction

Electronics A (TEI2B4) is one of the compulsory courses in the Electrical Engineering Bachelor study program of Telkom University. Based on the 2020 curriculum, this is a mandatory course in semester 4. During the Covid-19 pandemic, lectures were conducted synchronously with the use of online conference media and asynchronously with the Center for e-Learning and Open Education (CeLOE) Learning Management System (LMS) media. Lectures in even semesters were held twice a week (4 credits) which were held for 2 hours in each meeting.

The Electronics A course studies the characteristics of semiconductor materials, diode characteristics and application circuits, transistor circuit characteristics and analysis (BJT and FET), multilevel amplifier circuit analysis using transistors, as well as working principles and circuit analysis

with operational amplifiers. Furthermore, in this course students not only learn mathematical analysis, but are also taught additional skills, such as the use of software for simulation as a tool for circuit analysis. In the Learning Outcomes Program (PLO) of this course, students are expected to have the ability to analyze problems and conclude solutions mathematically.

The urgency of understanding Electronics in electrical engineering students is very significant. However, during the implementation of synchronous lectures, direct interaction does not exist due to the limitation of monitor screens in which the bond between students and lecturers are not properly established. Therefore, one of the components of successful learning, namely the interaction between lecturers and students, is not fulfilled (Rahman, Mutiani, & Putra, 2019). This affected the student's learning achievement in the 2019-2020 even semester. Out of the 311 students who took the Electronics course, there were 8.36% with a poor level of understanding (with a grade index of D), and 7.07% with a very poor understanding level (with a grade index of E). The percentage index of D and E scores in the electronics course represents the percentage of failures in the Electronics course. In the 2019-2020 even semester, student failure reached 15.43%. This percentage of failure is still above the expected limit value of 15% for Telkom University (Aprillia et al., 2020).

The implementation of online learning is not only due to the COVID-19 pandemic, but also important in the 4.0 industrial revolution era (Pangondian, Santosa, & Nugroho, 2019). Human resources (HR) that are adaptive to the demands are required to face the 4.0 industrial revolution era. Educational institutions, especially universities, plays an important role in preparing human resources by increasing the competence of graduates which have skills that are suitable to the 21st century era, namely learning and innovation skills (Zubaidah, 2018). The skills that must be mastered in the 21st century includes Communication, Collaboration, Critical Thinking and Problem Solving, and Creativity and Innovation (known also as 4C) (Zubaidah, 2018).

Based on the National Education Standards Agency (BSNP) there are four learning principles that must be met to meet the 21st Century criteria (Daryanto & Karim, 2017). The four principles of learning in question are: Student-centered learning, Education must be collaborative and contextual, and the University is able to facilitate students to be involved in their social environment. Therefore, the use of information and communication technology in all areas of life, including in the field of education, is a hallmark of 21st century education.

Presentation of open problems during learning is one method to improve 21st century skills (Yanuarni, 2019). Giving open questions can encourage critical and creative thinking in solving problems. Based on the results of observations (Khoiriyah & Husamah, 2018), problem-based learning (PBL) can improve the skills of year VII students in creative thinking and problem-solving skills. This is in line with research (Syam & Efwinda, 2019) which reports that the application of PBL can improve high-level thinking skills in Physics courses.

Based on the description of the problems that have been described, this study aims to implement PBL by utilizing the LMS CELOE media and analyze the effectiveness of the

implementation of PBL in the LMS CELOE media in achieving the 4C elements. In this study, only one element of the 4C achievement was observed, namely critical thinking & problem-solving skills.

2. Methods

The subjects of this study were lecturers and students participating in Electronics A course with a sample of 1 parallel class, namely EL-43-07 with a total of 34 students. Lecturers act as researchers as well as learning practitioners who are able to conduct self-observation objectively so that weaknesses that occur can be seen naturally, and can apply new learning methods that can improve students' abilities. The observer is one of the lecturers in the Electronics A course that occupy a different class as an observer of the performance of lecturers and students during the learning process.

The classroom action research (CAR) carried out applies the method initiated by Stephen Kemmis and Robbin Mc Taggart (Aprillia et al., 2020). There are four stages in this method, as shown in Figure 1.

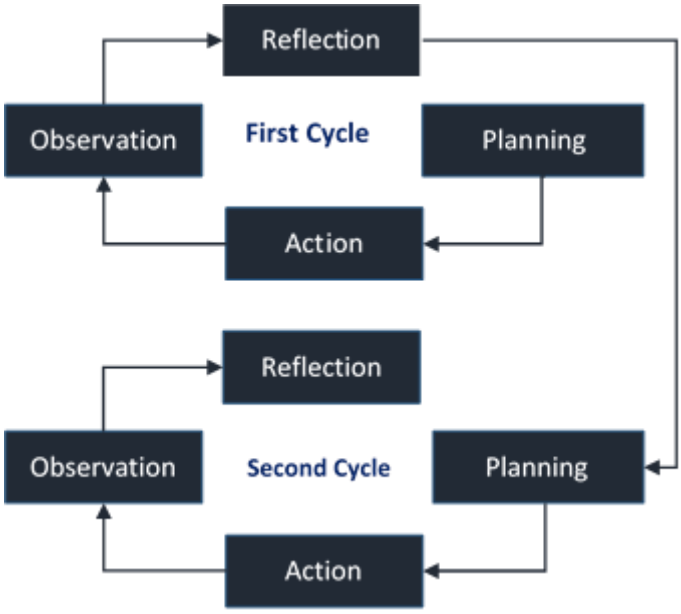

Figure 1. Kemmis – Taggart model

At the planning stage, identification of problems related to PBL effectiveness in LMS were conducted, formulation of problems related to PBL effectiveness in Electronics A which include mathematical analysis for the subject of BJT transistors with LMS media can achieve critical thinking skills. In preparation, assessment instrument consists of 1 pre-test, 2 post-tests, 3 forums, and 1 questionnaire. The planning stage was carried out on April 19th – May 3rd, 2021. The class action stage includes all actions contained in the Semester Learning Plan (SLP) by applying the PBL method. The direct observation stage is carried out by observing the tasks given starting from the pre-test to the post-test by filling in the rubric that has been determined and the results of the

analysis. While the indirect observation stage is done by making a questionnaire in the form of feedback from the students as the object of research in class EL-43-07. The reflection stage is carried out by reviewing, considering the results of various criteria or indicators of the success of the observations in each cycle. Classroom action research was carried out in two cycles as shown in Figure 1.

Measurement of effectiveness is seen from the extent to which the plans carried out are achieved or the level of success that can be achieved from a certain method or effort in accordance with the objectives to be achieved. In this case, the suitability of achieving the required learning outcomes based on the SLP stated in the learning outcomes achieved by the lecture participants above the class average results are measured. Another thing is the effectiveness of the required time in working on problems that arise in problem-based learning.

The measuring instrument used in this study are pre-test and post-test with the indicator results, students are able to model all transistor configurations and calculate the parameters in it, including in this case the achievements made by measuring the time level given in the PBL which must be completed within a certain time span. The 4C criteria element that was observed was only one of the criteria, namely the ability to think critically and problem solving which was associated with an existing rubric (Zubaidah, 2018) as shown in table 1.

Table 1. PBL value rubric on the achievement of critical thinking skills and problem solving

Index of Component	Components	Very Good (4)	Good (3)	Fair (2)	Poor (1)
C1	**Effectually analyze and evaluate problem**	Consistently and successfully analyze and evaluate problem.	Capable in analyzing and evaluating problem	Careless in evaluating problem	Not completing the analysis or evaluation of problem
C2	**Effectually analyze and evaluate the main points of an alternative point of view**	Capable to study problems from various points of view and not judgmental in evaluating problems	Non-judgmental during evaluating materials	Capable to analyze and evaluate problems from various points of view and not judgmental in evaluating problem, but to no avail	Doesn't respect other people's point of view during evaluating materials
C3	**Effectually synthesize and make connections between information and arguments**	Able to build perspective based on validated information and arguments.	Capable to make connections between information and arguments	Capable to make connections between information and arguments but unable to determine what they are doing on their own	Not trying to understand the relationship between information and argument

Table 1. Cont.

Index of Component	Components	Very Good (4)	Good (3)	Fair (2)	Poor (1)
C4	**Interpret information effectually and draw conclusions based on the best analysis**	Able to see complex information and successfully draw conclusions and according to the situation	Able to see information and draw conclusions successfully	Able to see information and sometimes be able to draw conclusions	Able to see information, and rarely able to draw conclusions
C5	**Critically reflect on experiences and learning processes**	Thoroughly reflect critically on experiences and learning processes and apply to future work	Reflect critically on experiences and learning processes	Strive to reflect on experiences and learning processes	Does not reflect the experience and learning process

3. Results and Discussion

The first cycle was carried out in LMS class EL-43-07 with an observation duration of 2 weeks starting from April 19th – May 3rd, 2021. The evaluation component of learning outcomes consisted of **1 pre-test, 2 post-tests, and a questionnaire** in the LMS. This first cycle is related to the material of the BJT type transistor. The problem in the pretest component is in the form of a BJT amplifier with a common emitter configuration, while the post-test is divided into 2, namely post-test 1, the BJT amplifier with a voltage divider configuration is given using mathematical analysis, for post-test 2 the same problem was given but using LTspice simulation approach. The results of the rubric in table 1 related to the measurement of the effectiveness of PBL that has been applied in the classroom to the ability to think critically and problem solving are shown in Figure 2.

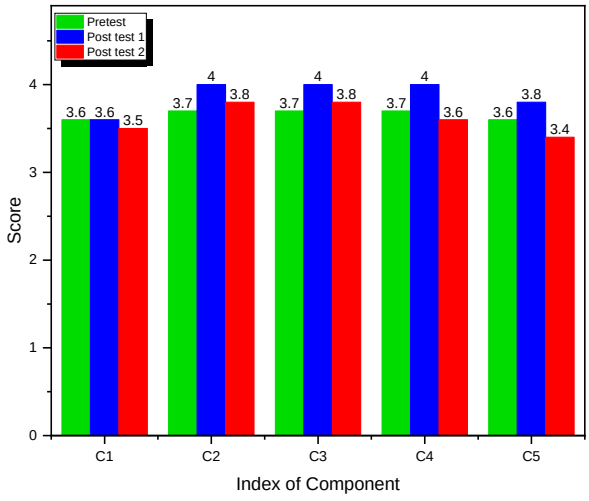

Figure 2. Comparison of critical thinking points in Pretest, Posttest 1 and 2 for Cycle 1

Posttest activity 1 in Figure 2, carried out on 22 – 28 April 2021 (7 x 24 hours) contains submitting mathematical analysis for transistor amplifier questions with voltage configurations followed by all groups. The increase in critical thinking points in the first post-test was triggered by an increase in the average value of learning outcomes which reached 10.7% higher than the average value of learning outcomes at the time of the pretest. An increase in learning outcomes at the time of the post-test indicates the influence of the PBL method that has been applied to improve student learning outcomes in electronics courses.

The post-test activity 2 was carried out in parallel with the post-test activity 1 containing the same questions as post-test activity 1 but using the LTspice simulation approach. The use of LTspice aims to find the correct answer in post-test 1. Based on Figure 1, the results of post-test 2 are lower because while the same values as post-test 1 should have been obtained, several mishaps which included 1 group's final results were incorrect because the simulation could only reach up to DC bias, 2 groups where the values of small ac signals did not appear, and 5 groups whose final results of small ac signals differ greatly from the results of the analysis in post-test 1 because of the use of low frequencies. There were 9 groups or 52.9% which managed the same final result as post-test 1 because they managed to export PBL in this simulation correctly. Therefore, as a result of reflection findings in the first cycle, the second cycle include simulations that approach the reality of measurement which will be tried by focusing on the critical thinking of students in the problem of differences in the results of analysis and measurement with simulations.

In general, the implementation of the second was not much different from the first cycle. This second cycle has been carried out in LMS class EL-43-07 with an observation duration of 2 weeks starting from 26 May – 6 June 2021, where there is 1 pretest, 2 posttests, and a questionnaire in the LMS. The second cycle is related to the material of the Field Effect Transistor (FET) type of transistor. For the pretest, the FET amplifier with common source configuration is given, while the post-test is divided into 2, namely post-test 1, the FET amplifier with voltage divider configuration is given using mathematical analysis. Post-test 2 comprised of the same problem but using LTspice simulation. The results of the implementation of the rubric in table 1 related to the measurement of the effectiveness of PBL that has been applied in the classroom to the ability to think critically and problem solving are shown in Figure 3. While table 2 shows a comparison of the results of the first and second cycle assessments.

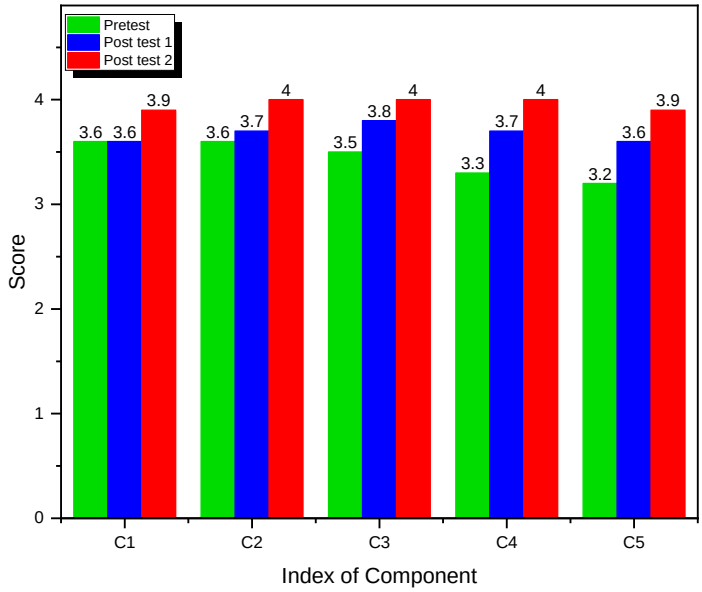

Figure 3. Comparison of critical thinking points in Pre-test, Post-test 1 and 2 for Cycle 2

Figure 2 shows that the average post-test 2 learning outcomes are higher than the pre-test. The learning outcomes in post-test 1 were compared with the pre-test learning outcomes, an increase in the value reached 3.6% that is, from 87.94 to 91.07 as shown in table 2. The increase in the value of learning outcomes was due to group discussions in the discussion forum during the work of the big project. Group discussions can help students in understanding the material given by the lecturer, the findings of this study are also consistent with the results of previous studies (Tugwell, 2020; Wahyuni & Widiarti, 2010).

Table 2. Comparison of learning outcomes in the first and second cycles

Scores	Cycle I	Cycle II
Pretest	87,65	75
Post-test 1 (mathematical analysis)	97,06	87,94
Post-test 2 (LTSpice simulation)	90,59	91,07

An increase in student learning outcomes in the Electronics course after the application of the PBL method as shown in table 2, is an indication of the effect of using the method in each cycle, which can be confirmed from the pre-test and post-test scores in each cycle. The pre-test in both cycles was carried out at the beginning of teaching and learning activities and there was no application of the PBL method while the post-test was carried out after a series of learning activities using the PBL method in LMS. The results of observations as shown in Figures 2 and 3 are justifications for the influence of the PBL method in LMS on increasing students' critical thinking abilities. Therefore, to measure the effectiveness of the PBL method in LMS, it is done by filling out questionnaires by students. Figure 4 shows the results of the questionnaire filled out by students participating in the Electronics course.

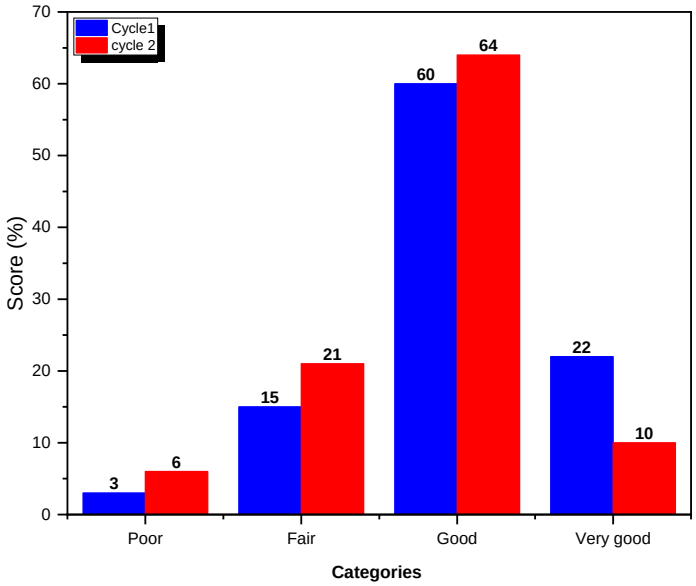

Figure 4. Student responses to the effectiveness of using the PBL method in LMS

Based on Figure 4, as a whole, the percentage of students in the two cycles which answered "Effective" consisted of 62% and "Very Effective" consisted of 16% of the students involved. This shows that the results of the questionnaire on classroom action research that were distributed to participants received a good response. So far, the effectiveness of the PBL method for Electronics subject in LMS in an effort to improve critical thinking, has a score of 78% and is effective.

4. Conclusion

Based on the results of observations and analysis of this study, several conclusions can be drawn related to the research question, namely Project Based Learning based on LMS is able to improve students' critical thinking and problem-solving abilities in the Electronics course. This statement can be confirmed from the results of repeated observations, namely the first and second cycles provide an increase in the post-test value compared to the pre-test value. The effectiveness level of the PBL method for Electronics subject in LMS in an effort to improve critical thinking, obtained a score of 78% and is effective.

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