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Effectiveness of Learning Electric Power System Transmission using Higher Other Thinking Skill based Simulation

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ABSTRACT

This study discusses the effectiveness of learning in the field of Electric Power Systems (EPS). The model developed by applying the Higher Other Thinking Skill (HOTS) strategy using computer simulation media at levels 4 and 5, from initial observations has not been optimal in improving learning outcomes in the EPT field. The HOTS strategy at the level of analysis and evaluation is indispensable in learning electric power transmission whose study material is abstract through complex mathematical modeling, thus requiring HOTS skills. The measurement of the effectiveness of EPS learning begins with a needs analysis, through 14 questions to identify learning needs, then builds an EPS simulation media and is also equipped with HOTS questions in the field of electrical power transmission. The Construct Modeling and Simulation (CMS) model was developed to implement the HOTS strategy in an effort to improve learning outcomes. Simulation as a learning media has been validated by 4 experts using Aiken's V approach with an assessment result of 0.86 which is declared valid. The effectiveness of EPS learning in the field of electric power transmission was tested on 22 students in the experimental class and 23 students in the control class. In the control class an inquiry model was applied, while in the experimental class a CMS-based simulation model was applied. From the results of the tests that have been carried out, the average value of learning outcomes in the experimental class is 78.53 and the control class is 68.37. The application of the simulation-based HOTS thinking skills strategy is effectively used by students in EPS learning and is effective in improving learning outcomes.

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1. INTRODUCTION

Skills in utilizing computer technology in learning affect student learning styles, testing was carried out on forty-six adults students enrolled in web-based special education courses, research results show the effect of the use of computer technology can overcome the problem of learning styles significantly on the acquisition of knowledge of adult learners, and there is a moderate positive correlation between computer skills and the learning success of adult students. And it can increase interaction between students so that it can increase the problem of learning outcomes which has been a dilemma for adult students (Rakap, 2010). Computers as learning aids are used in overcoming learning problems using simulations. Simulation concepts are applied to help understanding learning with studies that require high-level skills, effective active learning, have been applied to various professions such as pilots, business managers, military personnel and other professional fields. The use of computer-based simulations has been proven to have an impact on learning outcomes, seen from the results of research that show an increase in learning outcomes achievement of learning objectives and outcomes as well as improving skills in solving learning problems effectively. Computer applications in the form of simulations can increase students' confidence in the learning process to see the real situation using simulations (Curtin et al., 2011).

The application of computer technology can affect the behavior of students in daily learning and become a tool in increasing adult learning interest. This has been studied in Lamia, Greece. The trial involved adult students aged 18-65 years who participated in the study. Knowledge of computer technology is important for them, and increases the interest of adults to learn certain subjects by utilizing the use of computers and being a medium that can help in creative learning for adult learners (Giannoukos et al., 2016). Utilization of computer technology in the world of work is a necessity, so universities carry out various learning strategies using computer simulations for adult learning. This is part of responding to the needs of the world of work today, where skills in using computer technology for college graduates in 2022 are an absolute requirement for graduates to enter the world of work. As previously predicted, by 2022, skills in utilizing technology such as computer technology are increasingly needed by the world of work, as reported in the World Economic Forum report (WEF, 2018).

Utilization of technology as a strategy for applying critical thinking skills in learning. However, critical thinking skills for science and technology group students still not optimal compared to students of the social science group. The results of research on the perceptions of students (students) on critical thinking skills, as well as investigations on whether there are differences in gender and academic discipline on students' critical thinking skills in solving problems. The trial was conducted on a sample of 1000 students at 6 State Universities in Malaysia, showing that male students are perceived to have better critical thinking and problem-solving skills and that social science students appear to perform better in these skills compared to science and engineering students. technique (Merta Dhewa et al., 2017). This is in line with conditions in Indonesia, from the results of a survey released by the Organization for Economic Co-Operation and Development, that Indonesia is ranked 64 out of 65 countries. These results indicate that most students in Indonesia for the science field still have abilities that are not optimal when viewed from the cognitive aspect of knowing, applying, reasoning (Merta Dhewa et al., 2017). So that a strategy is needed to improve the quality of learning inthe fields of science and technology by applying various high-level skills, Higher Other Thinking Skills (HOTS), as well as the demands for strengthening human resources in Indonesia as referred to in the objectives of Law No. 12 of 2012 and the changing needs of the world of work in Indonesia. In the future world of work, the Ministry of Research, Technology and Higher Education through universities in Indonesia at the 2019 National Work Meeting, gave recommendations on aspects of Resources and Science and Technology, one of which is the learning process focused on aspects of access, quality and efficiency of learning, and at least have minimum competencies 4C (Communication, Collaborative, Critical Thinking, and Creativity) through various HR competency improvement programs (DIKTI, 2019).

In the field of science and technology at the higher education level it is still not optimal, this is based on research findings in the Physics course in Basic Electronics, analysis (C4) and skills in analyzing circuits and evaluating (C5) related to electronics. The trial was conducted on 47 students. From the results of the study, it was found that the low ability of students to think at higher levels was caused by students' difficulties in mathematical operations and system modeling for the electronics field being studied, besides that student had difficulties in analyzing various forms of circuits in the electronics field, so that learning outcomes were still dominated by students at the higher order thinking ability. or Lower Order Thinking (LOTS), while for the level of higher order thinking skills (HOTS) it seems that it is still not optimal (Erfan & Ratu, 2018).

HOTS critical thinking skills are implemented in learning through the application of technology with a simulation program. as a learning strategy for adults in science and technology. This has been compiled in the Indonesian National Qualifications Framework Scheme (KKNI) for level-1 education at level-6. Thinking skills in electrical engineering, including for electrical engineering courses, can be done with the help of computer technology in the form of visualization and simulation in his research entitled Critical Thinking in Electrical and Computer Engineering. Critical thinking in the field of Electrical and Computer Engineering, the results of research with statistical tests show a significant increase in critical thinking skills in electrical courses/learning using computer aids (Welch et al., 2015).

Simulations using application programs in learning are used to increase students' learning motivation in learning, increase learning independence and be able to conduct experiments that are modeled virtually from the real situation in a computer simulation design (Maharani, 2018). Simulation can be applied through dynamic modeling of electric power systems presented in a mathematical model implemented in a software-aided simulation model. The performance of the simulation results can have a strengthening and motivational effect in learning activities (Shahir et al., 2012). Simulation tools have been applied in learning at universities such as the Electrical Transient Program at Curtin University. Simulations are used in project-based Electric Power System Protectionlearning, in the field of electric power system studies (Shahnia et al., 2014). In line with the research conducted by Gashimov, he has carried out simulation trials for controlled shunt reactor modeling for experimental loss measurement and dynamic operating performance of the system using a computer program (Gashimov et al., 2015). The simulation process in the field of electrical engineering is carried out by applying mathematical model equations and compiling a data base. The application of modeling and mathematical equations is used to view the system's performance graphically and parametric results that describe the real situation in the electric power system (Junaidi et al., 2021).

The electric power transmission system is an important field for university graduates in the electrical engineering study program. The need for planning and developing a transmission system is no longer done intuitively, but a strategic planner is needed by utilizing analysis and synthesis tools in analysis activities, such as (1) transmission routes, identification and selection of transmissions, (2) planning for transmission network expansion, (3) Analysis of the transmission network and (4)Analysis of reliability (Gonen, 2015). Learning concepts using models that are suitable for adult learners, the use of computer technology and strategies in applying them in electric power system learning, are important to improve the quality of college graduates, especially in the field of electrical engineering in responding to the challenges of the world of work in 2022 and the future.

Technology has revolutionized the world of education. The importance of technology applied in learning in higher education must be an important consideration, in line with the research submitted on the role of computer technology in education as a tool to help educators, provide convenience in conveying knowledge and knowledge and for students. The use of technology has made the teaching and learning process more enjoyable for students (R. Raja & P. C. Nagasburani, 2018) Learning outcomes can be increased also through optimizing learning effectiveness through the learning environment and student learning motivation, can be influenced by the learning environment and student motivation in learning (Ahmad, 2021).

2. METHODS

2.1 Research Instruments

There are two types of data collection instruments used in this study, namely (a) questionnaire, and (b) interview/observation rubric, as the main tool in observing research data. Questionnaires are used to search for information related to the specification of the data being searched. The compiled questionnaire is used for tracer studies, needs assessment and assessment of research products, with the substance of the questions in the questionnaire in accordance with the required data collection. The assessment questionnaire from the respondents was compiled with the linkert scale assessment criteria. The statements described in the questionnaire to the respondents are arranged with scores and the selection of a description of the contents of the questionnaire in accordance with the criteria for needs. The instruments used in the study were validated by experts, to measure the feasibility of the instruments used so that the measurement results became more objective and correct.

2.2 Content Validation of Teaching Module Products

Teaching modules from research products are prepared as part of the results of development research, validated by 5 experts. The model book content validation instrument has 4 aspects with a total indicator of 31 items. The 4 aspects include: (a) Organization, 6 indicators (b) Writing format, 8 indicators (c) Content aspect, 14 indicators and (d) Language use 3 indicators. Test the validity with data processing using the Aikens'V model. Tabulations and calculations of the items assessed by experts can be seen and the results of the analysis using the Aiken's V approach. The assessment is done by giving a number 1 (which can be interpreted as very unrepresentative) to 5 (which can be interpreted as very representative or very relevant), while the statistical formulation of Aiken's V according in the mathematical formulation of equation 1 to identify validity content, expressed by:

$$V = \frac{\sum S}{n(C-1)}$$

Formula description:

$S = r\text{-}l_o$

l_o = The lowest validity rating score (in this case = 1)

C = The highest validity rating score (in this case = 5).

2.3 Practical Test

Practical test instruments are carried out to test the products used after going through a revision process from products that have been validated by experts. The practicality test is carried out by analyzing the instruments given to the user through filling out questionnaires, interviews. The practicality test analysis process is carried out to determine the level of practicality of the model.

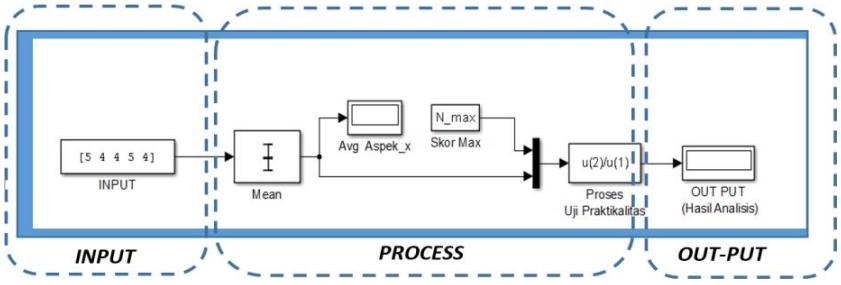

Figure.1. Block Diagram Concept Model and Analysis for Practical Test

From figure 1, The input block is the data entry resulting from the tabulation of the respondent (lecturer or student) from the questionnaire filled out by the respondent, then tabulates as well as modeling the input by entering (entry) data. The amount of data entered is determined based on the number of indicators contained in the questionnaire distributed to respondents. Process block is a mathematical modeling of input data based on practicality test equations in order to analyze the level

of practical achievement of the developed model. Out-put block in Simulink matlab is a display tool that is used to observe the analysis results of the process block. The result parameters displayed on the display are a presentation of the level of practicality of the developed model, so it can be concluded whether the developed model is included in the category of very practical, practical, quite practical, less practical or impractical.

2.4 Effectiveness Test Model

The effectiveness test of the limited class and the extended class were analyzed to see valid values, missing values, mean, Std. Deviation, Std. Errors of Mean, Maximum and Minimum. With thehelp of Simulink matlab, all parameters were observed from the results of the MATLAB simulation. The respective equation formulations are written in table 1.

Tabel 1. Equation Formulation used in Modeling and Simulation for Effectiveness Test

Itema	Description	Formulation
Mean	where Σ is the sign of addition (sum), X is each number, and N is the population size	$\mu = \frac{\sum X}{N}$
Std. Deviation	The standard deviation, for purely real or purely imaginary inputs, the standard deviation of j column of the M-by-N input matrix is the square root of the variance, written by the equation	$y_j = \sigma_j = \sqrt{\frac{\sum_{i=1}^{M} \lvert u_{ij} - \mu_j \rvert^2}{M-1}}$ $1 \leq j \leq N$
Std. Error of Mean	Is a value that can be interpreted by how close the average (Mean) of the sample to the population. The larger the sample, the smaller the standard error, and the closer the sample mean approach is to the population mean	*Standar error* = $\frac{\sigma}{\sqrt{N}}$

3. FINDINGS AND DISCUSSION

3.1 Instrument Validation Results

Instrument validation by experts is carried out to determine the suitability of the instrument used, so as to avoid errors in measurement. The Aiken'V approach is used in determining thesuitability value of the instrument used. from the results of the analysis in figure 2, it shows the average value of the validation results is 0.86, indicating that the needs analysis instrument is suitablefor use in research.

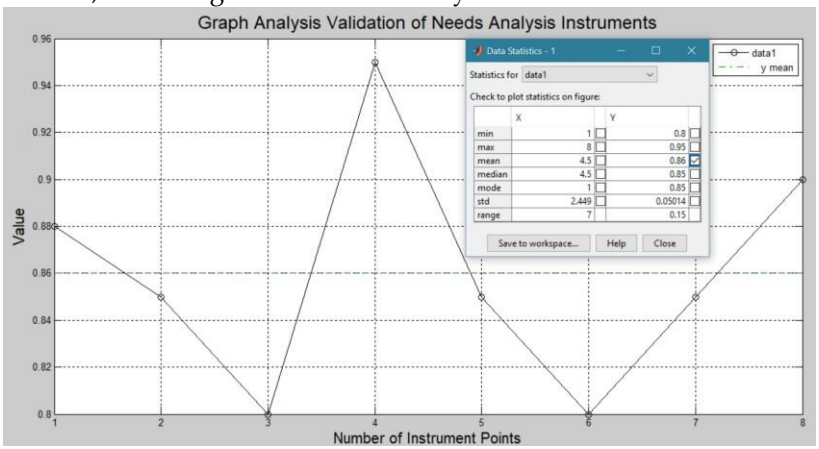

Figure 2. Instrument validation results

Figure 2, shows a graphic plot of the assessment of the needs analysis questionnaire instrument used which was given to 4 experts. The instrument was validated to measure the feasibility of the

questionnaire used, it can be used as a measuring tool. There are 8 aspect points contained in the validated instrument, namely: (1). Language Aspects, (2) Instrument Content Aspects, (3) the weight of the assessment range (4). The suitability of the question with the need for observation (5). Ease of understanding instrument language in operational definition aspects (6). The suitability of teaching materials with lesson plans. (8) There are suggestions on the instrument as a statement of feedback and conformity. The eight aspects analyzed on the graph are shown at the connection points along thex-axis (8 indicator points). While the value parameter on the y-axis is the average result of 4 experts who assess each point of learning material needs. After plotting the graph, then the overall average value is taken, the graph shows the overall average value for the analysis of the material needs of the fault 0.86, in the instrument category it can be used as an observation tool in research

3.2Need analysis data.

Needs analysis is carried out to identify the material needs to be taught in electrical power transmission courses. Validator material experts three people in electricity experts, given in table 2.

Table 2. Expert Validators

No	Expert validator name	Areas of expertise
1	Dr. E.M, MT	Electrical Engineering
2	Dr. D. N S.Kom., M.Kom	Information Systems
3	Dr. Is. M.Kom	Technology and Vocational Education

Expert validators assess the aspects of the material being taught with 8 components, a total of 34 points of sub-material aspects that are assessed by the validators. 8 components consist of (1) Basic Concept of Electric Power System, (2) Transmission Line Resistance, (3) Transmission Line Inductance, (4) Capacitance and Capacitive Reactance, (5) Short Distance Transmission Line, (6)Medium Distance Transmission Line (7) Medium Distance Transmission Line, (8) Long Distance Transmission Line. the results of the expert assessment in the needs analysis are shown in figure 3.

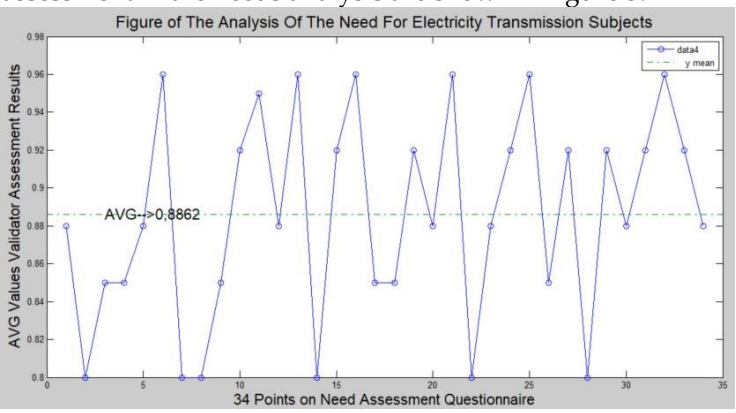

Figure 3. Results of needs analysis

Figure 3, is a response plot to the assessment of 34 sub-subject points of electrical power transmission material assessed by experts. The results show an average rating of 0.886 (greater than 0.80 in the category of urgently needed), in this case, in line with what was conveyed in james' research, regarding thinking skills in learning the field of electrical engineering in the electricity sub- material field requires computer technology aids in the form of visualization and simulation (James, 2012).

3.3 Analysis results Validation of module product content

The results of the analysis the validation of the product content of the module is carried out by simulating calculations shown in figure 4. Based on the data distributed to the experts, to test the content of the modules used in learning. In the instrument there are 34 questions with an assessment score ranging from 1 to 5. The simulation results of the product content validity test show that the content of the module book is valid for use in learning, with HOTS criteria, accompanied by HOTS questions in the module.

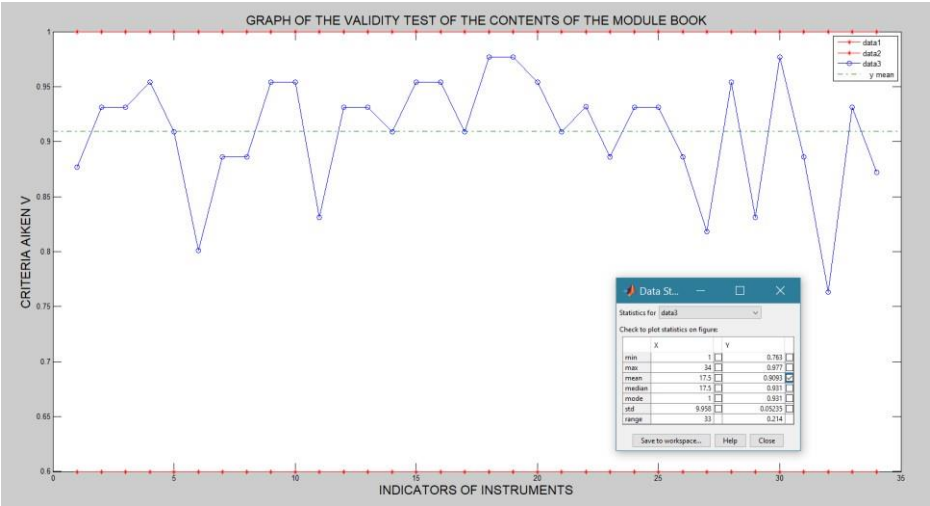

Figure 4. Results validation of module product content

Figure 4 shows a summary of the content validity test of the development product. Data analysis uses Aiken's V approach which states that the content validity of an element is declared valid if the coefficient of analysis based on Aiken's V approach is $0{,}6 \leq V \leq 1$. The average result of the assessment of the module content is 0.9093, based on the Aiken V criteria, it is declared valid. This is in line with the research conducted by Darmawan (2015), the results of testing on 55 respondents were tested for the coefficient of the average value of validation based on the Aiken's V approach, which was obtained at 0.83 and was declared significant to meet the content validity criteria of research on validity and reliability studies for the success factors of E-Government, as well as Retnawati's research (2016) used the Aiken's V index in testing content validity with the test result index coefficient of 0.8.

3.4 Practical data analysis results

Practicality data analysis is used to measure how practical the product is easy to use by users. Users involved in the study consisted of 4 lecturers who used the module. The results of the assessment of the practicality test are shown in figure 5.

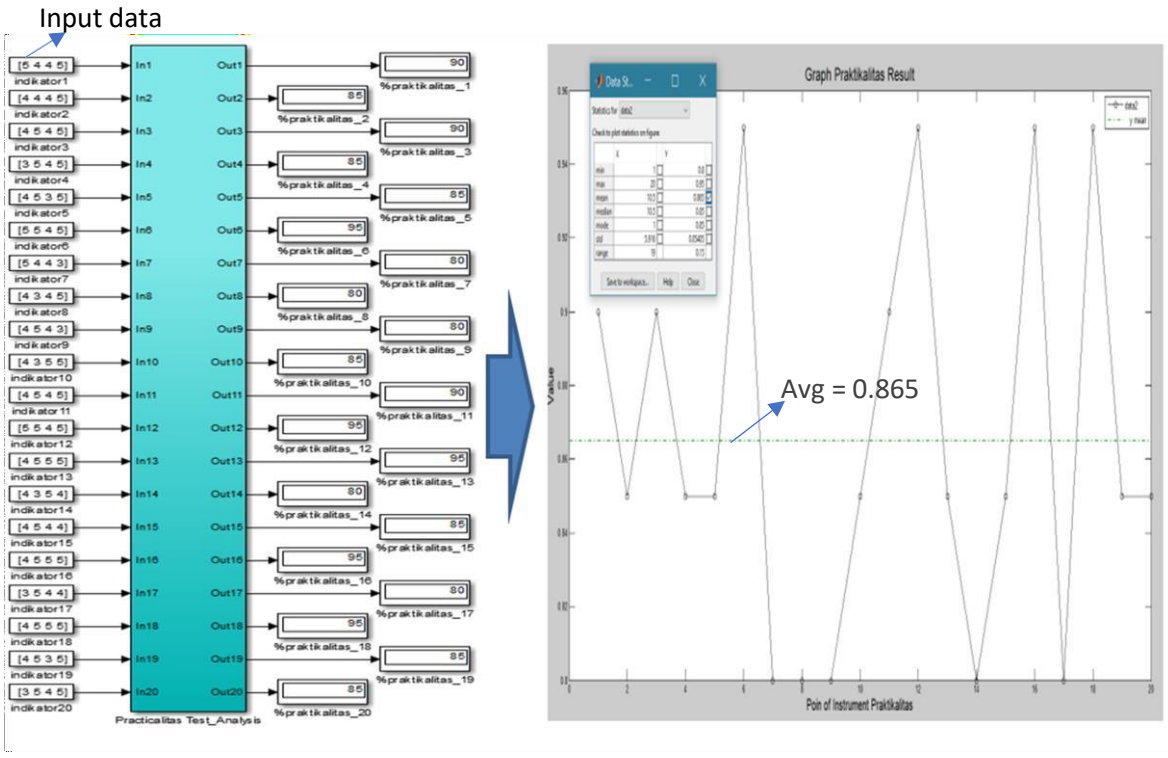

Figure 5. Practical data analysis results

Figure 4, shows a practical test simulation using the Simulink software. The simulation of the assessment of the practicality of the module product produced in the study, tested by 4 users, showed an average result of 0.865. Based on the Aiken V criteria that is $0{,}6 \leq Aiken\ V \leq 1$, the formulation used shows that the module book product is easy to use by users.

3.5 Effectiveness Test Results

The effectiveness test on 23 student respondents in the experimental class compared to the control class is intended to find out how much influence the use of the CMS model has in the learning process. To determine the effect of the model on learning, it wascompared with the control class which was treated with the direct learning model (DL). The effectiveness test process for the experimental class from the score was carried out through post-test value analysis through simulation of data calculations obtained: The average value of the pretest of the control class is 62,48, and the experimental class is 63,33. While the average value of the posttestof the control class is 68,37 and the average value of the experimental class is 78,53, ss shown in figure 6.

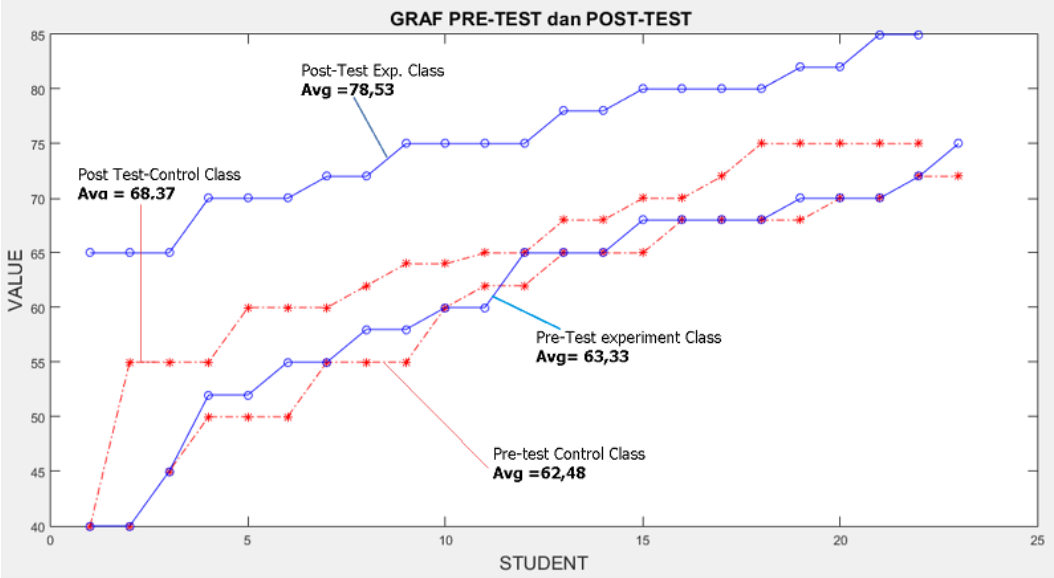

Figure 6. Effectiveness Test Results

Figure 6 shows the, the effectiveness of learning is measured by multiple choice questions to measure cognitive aspects. In the aspect of affective assessment, the observation rubric is carried out, while the student skill test is carried out with a simulation project with a mini research report. The analysis of the effectiveness test on the model proposed in the research with a scientific approach of pre-test and post-test showed that the average learning outcome for the experimental class was 78.53, which previously had an average score of 63.33. In the control class 68.37 which was previously 62.48. according to the trial (Firman et al., 2018) which conducted a trial of the experimental class after using the learning module developed from 85.00 from the previous with a value of 65.00, and the control class with an average of 78.00 from the previous value of 66.00.

This shows that the application of learning strategies with simulation media has a good impact on effectively improving learning outcomes, this shows that the application of learning strategies with simulation media has a good impact on effectively improving learning outcomes

Analysis of learning outcomes of the three aspects is shown in table 3.

Table 3. Summary of test results (Cognitive, Affective and Psychomotor Aspects)

No	Effectiveness Test	Average value		The value of learning on aspects of Psychomotor	The value of learning on aspects of Affective
		Pre-Test	Post-Test		
1	Control Class	62,48	68,37	60,17	Rating Mode: Good Grade
2	Experiment Class	63,33	78,53	80,37	Rating Mode: Good Grade

In table 3. The test results on the cognitive aspect of the class with a HOTS-based simulation program in the experiment class with a posttest score of 78.53 higher than the control class with an average value of 68.73, obtained from the post-test results, while the psychomotor aspect it can be seen that the experimental class learning outcomes s 80.37 is higher than the control class with a valueof 60.17. In the affective aspect, both the control class and the experimental class, through observations at a good grade. The use of simulation can improve learning outcomes and skills, according to research conducted by (Nurkanti, Utari, & Devi, 2019). Research observations related to the use of Interactive Visual Multimedia learning media can improve student learning outcomes in the topic of the human movement system with moderate N-Gain 0.69 for affective aspects well category score 85, psychomotor aspect score 86 and student responses showed 79% of students had a positive response to learning.

4. CONCLUSION

Tests and analyzes that have been carried out for the CMS model in electric power transmission learning, can be concluded:

1. The CMS development model which is based on the HOTS characteristics of the validity test of the experts on the product development output produces a practical module product that is declared suitable for use in learning the field of Transmission Technology Engineering.
2. The products produced in the study have been tested for practicality, from the results of the product practicality test from the development of a simulation-based CMS model, it is stated that the module book is valid and easy to use by users in learning electric power transmission.
3. The effectiveness test for the control class and the experimental class each has a change in student learning outcomes. In the control class using the DL model, there are differences in the average learning outcomes. This shows that the CMS model applied to the experimental class is more effective than the control class. Psychomotor assessment in the experimental class is higher than the average assessment of the control class. While the attitude assessment in the control class and the experimental class of 27 students in each class has a mode value on the aspect of thesame attitude value, which is good.
4. The use of a simulation program based on the CMS syntax as a HOTS strategy has an impact on improving learning outcomes that are tested in the experimental class. Students can search for errors from work solving cases in the transmission field analytically and evaluatively, can perform scientific truth searches independently, which characterizes level 4 and level 5 in Blom's taxonomy, as a marker of the level of HOTS skills. This impact can be seen from the learning outcomes on the psychomotor aspect with the average value of the experimental class learning outcomes treated with the Simulation-based HOTS Strategy is higher than the control class giventhe inquary model treatment.

Research trials were carried out in classes that were homogeneous for students taking electrical power transmission courses. It is hoped that further research will implement the Simulation-based CMS model in solving real problems through internship activities or student assistance for field/industry observations through Cooperation schemes with the business or industrial world. So that this simulation-based CMS model can be applied directly to solve real problems. This research was supported by independent lecturer research funding facilitated by the LPDP of the Ministry of Finance. Hopefully, in further research, it is hoped that it can be implemented in real terms in solving real problems in the industry with the help of simulation technology, in the field of study being researched.

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