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Implementation of Trainer Kits in Project-Based Learning to Improve Critical Thinking, Motivation, and Competency of Electrical Engineering Students

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ABSTRAK

Abstract: Innovation of Project-based learning (PjBL) in the 21st century continues to be developed to improve learning outcomes. The use of Trainer kits presents several challenges in achieving learning objectives, both in terms of design, planning, and implementation. The purpose of this study is to implement the Automation of Electrical Installation trainer kit in project-based learning to increase student motivation, critical thinking, and competence. The research method uses research and development (R and D) with 4 models (Define, Design, Develop, Disseminate). Data collection techniques used theory tests and performance tests (measure of maximum performance type, MMP) and questionnaires (measure of typical performance type, MTP). The research trial used 120 respondents of final-level electrical engineering students from 3 universities in Surabaya, Indonesia. The resulting test of statistical analysis Wilcoxon using SPSS-23 obtained Asymp. Sig. (2-tailed) is valuable 0.000, meaning that there is an increase in the quality of learning on critical thinking skills, motivation, and competence of Electrical Engineering students by implementing a trainer kit in project-based learning.

Abstrak: Inovasi Pembelajaran Berbasis Proyek di abad 21 terus dikembangkan untuk meningkatkan hasil belajar. Penggunaan Trainer kit menghadirkan beberapa tantangan dalam mencapai tujuan pembelajaran, baik dari segi desain, perencanaan, maupun implementasi. Tujuan dari penelitian ini adalah untuk mengimplementasikan trainer kit Otomasi Instalasi Listrik dalam pembelajaran berbasis proyek untuk meningkatkan motivasi, berpikir kritis, dan kompetensi siswa. Metode penelitian menggunakan research and development (R and D) dengan 4 model (*Define, Design, Develop, Disseminate*). Teknik pengumpulan data menggunakan tes teori dan tes kinerja (ukuran tipe kinerja maksimum, MMP) dan kuesioner (ukuran tipe kinerja tipikal, MTP). Uji coba penelitian ini menggunakan 120 responden mahasiswa teknik elektro tingkat akhir dari tiga universitas di Surabaya, Indonesia. Hasil uji analisis statistik Wilcoxon menggunakan SPSS-23 diperoleh Asymp. Tanda tangan (2-tailed) bernilai 0,000, artinya terdapat peningkatan kualitas pembelajaran keterampilan berpikir kritis, motivasi, dan kompetensi mahasiswa Teknik Elektro dengan menerapkan trainer kit dalam pembelajaran berbasis proyek.

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Learning innovations continue to be developed in improving learning outcomes for college students. Learning outcomes are abilities obtained through internalization of knowledge, attitudes, skills, competencies, and accumulated work experience (kemenristekditi, 2015). Currently, with the development of information technology, real-time and reliable devices have been developed to support learning in the classroom or in the laboratory. The development of a trainer kit of electrical installation automation that is oriented towards industrial needs is an important part of increasing learning motivation, critical thinking, and competence of engineering students. The trainer kit combined with the authentic learning model helps students to grow introspective maturity in dealing with learning problems. According to Järvelä and Renninger (2014), students need introspective maturity in dealing with learning problems, and the process of integrating attitudes in a series of actions with thinking skills, which enables the achievement of competencies and learning objectives through professional action.

Professional action in the field of education in the global era is competency-based education (Hernández & Morales, 2016). Competency-based education (CBE) is a methodology that focuses on giving students the skills demanded by industry and evaluating them on what they can do (Johnstone and Louis Soares, 2014). The biggest strength of CBE is the availability of adequate facilities in the learning process to maintain the quality and objectives achieved. CBE is a reorientation of the educational process towards mastery and application of knowledge and skills in the real world of the 21st-century. This reorientation builds bridges between academics and stakeholders, resulting in a better understanding of the knowledge and skills students need to succeed in work and life.

Knowledge, skills, and attitudes are the main aspects that affect the competence of college students. When college students can achieve these competencies, it can be said that these students are able to master the subject matter and succeed in learning. According to Kagermann, et al. (2013), the skills and competencies of human resources as technology users are the key to industrial competitiveness. The skills and competencies of the Electrical Installation Automation engineering process are becoming increasingly relevant and important for the implementation of skilled workers in production. 21st century skills with the 4th Industrial revolution is a new paradigm that brings a whole change. New paradigms in organizational processes and production work must shift along with the development of real-time automation and control (Spoettl & Tūtlys, 2020).

Compared to the standard curriculum, 21st-century skills are very concrete. Students are required to have critical thinking and creative thinking, skills in using information media and technology, and be able to work, and be able to survive and develop themselves into professionals by using life skills (ATC21S, 2014) (Lee, Huh & Reigeluth, 2015). Furthermore, critical thinking is one of the characteristics or skills of 21st-century learning that needs to be developed based on the results of research from 250 researchers from 60 world institutions who are members of ATC21S (Assessment & Teaching of 21st-Century Skills). The use of critical thinking in learning can be translated as better-quality understanding of theories, evidence, and important issues through scientific work and the application of various subjects in real-world contexts (Montebello, et al., 2018). Critical thinking is a skill that is acquired through a process, so there needs to be an effort on how to teach and invite critical thinking to students through the selection of meaningful learning models.

Critical thinking is meaningless without an intellectual process (Hanna, 2013). Self-awareness, confrontation of beliefs and emotions are self-motivation in intellectual processes that are integrated during learning (Fukuzawa, Boyd, and Cahn, 2017). Many factors can influence learning behaviour, and some of them will have a positive influence if these factors are combined (Palmer, 2016). Self-motivation in achievement may not be directly taught but through an integrated process of habituation of students in learning and practicing (Sari, 2018). By making some modifications to the model, the implicit decision-making process can be responsible for increasing the activation of learning behaviour.

Project-based learning (PjBL) is a meaningful learning model (Bell, 2010). Project-based learning (PjBL) is a meaningful learning model. PjBL can be integrated into the 21st century learning curriculum to significantly improve the quality of learning (Hutchison, 2015). Project-based learning is a learning model based on constructivism that supports student involvement in problem solving situations and the analysis or evaluation process, so that the knowledge gained is more permanent (Doppelt, 2003). Furthermore, Lasauskiene and Rauduvaite (2015) stated that PjBL helps educators in encouraging students to develop collaboration skills, increase critical thinking and creative thinking, solve complex problems, transfer learning, and have a positive attitude towards assignments. PjBL is a learning model that encourages students' motivation on critical thinking skills to solve problems with the displayed and presented final product, solving these problems can be done individually or in groups with a certain period together. PjBL is a learning model that encourages students' motivation with critical thinking skills to solve problems with the final product to be displayed and presented, solving these problems can be done individually or in groups with a certain period together (Chiang and Lee, 2016).

Seeing the advantages of "Project-Based Learning", this study aims to combine learning development innovations with the trainer kits of electrical installation automation in PjBL. The implementation of the trainer kit in project-based learning functions to increase student learning motivation through meaningful learning, knowledge and problem-solving skills, critical thinking, and competence. In addition, this combination of learning can be used as the right solution in helping lecturers improve learning outcomes in implementing CBE for Electrical Engineering students. It is hoped that the development of this model can be used as an evaluation system for integrated learning models in the curriculum.

METHODS

The actualization of this research is focused on Research and Development following the design of the 4-D model. The research design used a quasi-experimental design using One Group Pretest-Posttest Design. This design was carried out by giving a pretest to the research sample in the experimental class. Furthermore, giving treatment to the experimental class with a project-based learning model using the trainer kit of electrical installation automation. Learning outcomes are achieved if the college student's post-test score is > 70 (B).

Table 1. Research Design One Group Pretest – Posttest

Group	Pre-Test	Treatment	Post Test
Experiment	01	X	02

Source: Johnson, and Christensen (2017)

The research was conducted in January 2019—April 2020 at 3 universities located in Surabaya, Indonesia. This study involved 120 samples of final-year Electrical Engineering students. The object of the research is the teaching material for Electrical Installation which is innovated into a project-based learning package. PjBl is designed to use the trainer kit of Electrical Installation Automation to strengthen material in lectures.

The research instruments used include project-based learning packages, questionnaires, and learning evaluations (tests). The data collection technique uses a theory test and a performance test (measure of maximum performance type, MMP), and questionnaires (measure of typical performance type, MTP). The mechanism for collecting research data is carried out following the procedure according to figure 1.

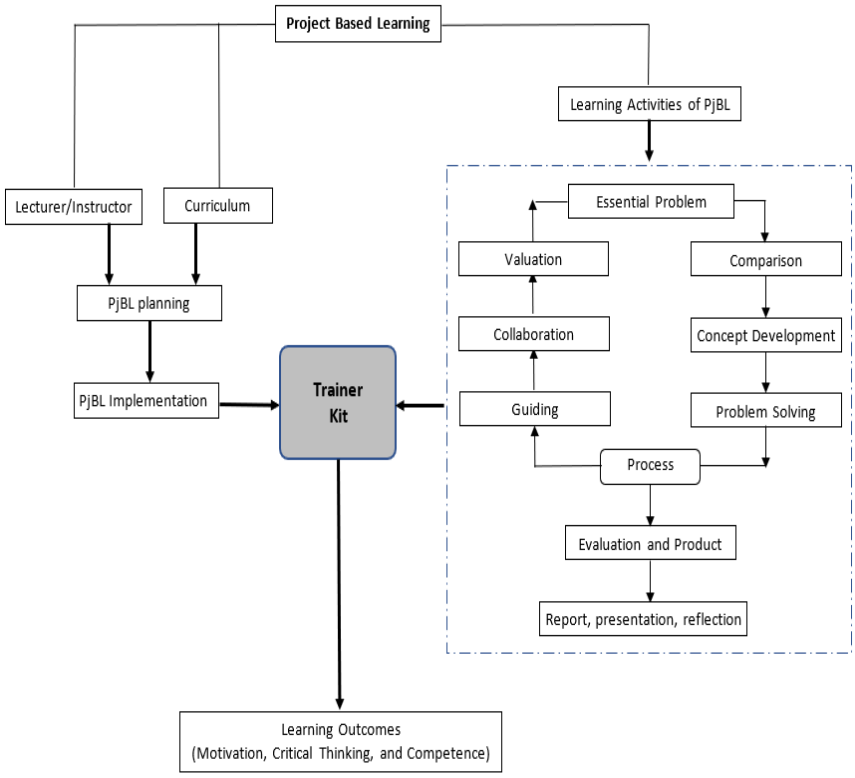

Figure 1. Mechanism of Trainer Kit implementation in PjBL

The hypothesis analysis technique uses non-parametric statistical testing with the Wilcoxon test assisted by SPSS-23. The Wilcoxon test was used because the data were not normally distributed. This analysis technique is used to determine the average difference to the increase in the measured variables. The hypotheses formulated in this study: a) H0: accepted, if the value of Asymp. Sig. ≤ 0.05, meaning that there is an increase in learning outcomes, and b) H1: rejected, if the Asymp value. Sig. ≥ 0.05, meaning that there is no increase in learning outcomes.

RESULT AND DISCUSSION

Experimental research with the approach model research and development starting from define, design, developing, and dissemination has been tested for validity and reliability. This is in accordance with the opinion of Mohamad, *et. al.* (2015) who said that to obtain accurate information, a valid and reliable instrument was needed. The number of experts involved in the validation of this instrument was 9 academics (7 engineering experts, 1 learning expert, and 1 linguist expert) and 3 practitioners/stakeholders. The results of the validator's assessment of the trainer kits and job sheet instruments developed are Very Good (3.86), meaning that they can be used for assessment.

The results of the inter-rater validity test on the items of the critical thinking instrument using the Aiken V index equation of 0.820 with a high validity category (very good), that is, the validator's state that the critical thinking skills test instrument designed by the researcher is worth testing so that its characteristics can be known. Furthermore, the reliability test (consistency) of critical thinking instrument items was carried out using the Test Analysis Program (TAP) software. Table 2 shows the results of the critical thinking instrument analysis test with Kuder Richardson-20 (KR 20) which resembles the Cronbach Alpha coefficient of 0.843 which means that the item is close to 1.00, so the overall reliability of the item is in the range of excellent (reliable).

Table 2. Results of the Descriptive Analysis of The Items Instrument

Criteria	Analysis Results
Number of Items Analyzed	50
Mean Item Difficulty	0.560
Mean Discrimination Index	0.333
Mean Point Biserial	0.339
Mean Adj. Point Biserial	0.289
KR20 (Alpha)	0.843
KR21	0.783
SEM (from KR20)	2.883
# Potential Problem Items	11

Furthermore, as a comparison of confidence or trust in the accuracy of the items instrument test, it can be seen in table 2 from the Standard Error of Measurement (SEM) score. SEM is an estimate of the standard deviation of measurement error for each test/scale, the better the reliability of the item, the score SEM is getting smaller. The SEM score of KR20 (table 2) shows 2.883, meaning that the low critical thinking test instrument item can be trusted or trusted as a measuring tool. After the trainer kit instrument is declared valid and reliable, it can be tested in an integrated manner in project-based learning to increase motivation, critical thinking, and competence of electrical engineering students.

The results of the descriptive statistical test analysis of improvement using SPSS version 23 are shown in table 3, descriptive statistics show the description and exposure of the distribution of research data (before and after learning) including the number of data samples, minimum values, maximum values, average values, and standard deviation. These results can be used as a basis for further analysis tests on measuring motivation, critical thinking, and student competence on The materials of Electrical Installation Automation.

Table 3. The result of Descriptive Statistical Analysis

	N	Minimum	Maximum		Mean	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std Error	Statistic
Pre-Motivation	120	61	84	70.39	274	4.761
Post Motivation	120	70	94	83.46	246	4.266
Pre-Critical Thinking	120	58	81	71.10	338	5.875
Post Critical Thinking	120	72	100	83.22	261	4.544
Pre-Competence	120	63	77	70.80	156	2.714
Post Competence	120	79	92	85.38	127	2.199
Valid N (listwise)	120					

Based on the results of the initial evaluation (table 3), it is known that students' mastery of electrical installation automation according to the Electrical Installation Curriculum is low. The results of data collection before teaching treatment (pre-learning) showed that students were motivated, critical thinking and competence in Electrical Installation Automation material, which was still below the set value 70, although statistically the average for each variable had met the specified value.

Furthermore, the learning is continued by giving treatment for the implementation of the Electrical Installation Automation Trainer Kit in Project-based Learning (post learning). The results of descriptive statistical analysis showed an increase in motivation, critical thinking, and competence of electrical engineering students with a minimum score of 70 with the overall standard deviation (motivation, critical thinking, and competence) lower than the learning activities before treatment. The results of this analysis are in line with the statement of Auludin & Taruno (2017), that the competency base in the implications of measuring student progress is more emphasized and centred on participants in positive work attitudes, mastery of knowledge, and skills. Positive attitudes arising from the implementation of the trainer kit in project-based learning will have a deeper influence on the intrinsic motivation and knowledge directly of students (Fukuzawa, et al. 2017).

Measurement of the significance of the increase in learning outcomes between 2 groups of paired data was carried out by statistical analysis using the Wilcoxon test. Table 4 is the result of the ranks test-Wilcoxon, where the negative ranks on each variable (motivation, critical thinking, and competence) are 0, meaning that there is no decrease (reduction) from assessment before treatment to assessment after treatment. Positive ranks show the value for the mean rank of 60.50 and the Sum of ranks 7260, meaning that 120 samples experienced an increase in learning on motivation, critical thinking, and student competence. Ties value is 0, meaning that there is no similarity in the scores obtained by students before and after learning.

Table 4. The Result of Ranks Test

Tables 1	Tables 2	Tables N 3	Tables Mean Rank 4	Tables Sum of Ranks 5
Post Motivation Pre Motivation	Negative Ranks	O[a]	.00	.00
	Positive Ranks	1206	60.50	7260.00
	Ties	O[c]		
	Total	120		
Post Critical Thinking Pre-Critical Thinking	Negative Ranks	O[a]	.00	.00
	Positive Ranks	1206	60.50	7260.000
	Ties	O[c]		
	Total	120		
Post Competence - Pre Competence	Negative Ranks	O[a]	.00	.00
	Positive Ranks	1206	60.50	7260.00
	Ties	O[c]		
	Total	120		

Table 5. Statistic Test – Wilcoxon

	Post Motivation-Pre-Motivation	Post Critical Thinking-Pre-Critical Thinking	Post Competence-Pre-Competence
Z	-9.511b	-9.511b	-9.511b
Asymp. Sig. (2-tailed)	.000	.000	.000

Based on the output of "statistical test - Wilcoxon" (table 5), it is known that Asymp. Sig. (2-tailed) is 0.000 < 0.05 for all variables, it can be concluded that H0 is accepted and H1 is rejected, this means that there is an increase in learning outcomes in the application of trainer kits electrical installation automation in project-based learning on critical thinking, motivation, and competence. Furthermore, PjBL can improve long-term content retention, improve problem-solving and collaboration skills, and improve student attitudes towards learning (Radovan & Kacovec, 2015). Here it is clear the impact of project learning in improving critical thinking and learning motivation of Electrical Engineering students. In line with the statement of Tiwari, Kumar Arya, & Bansal (2017), that project-based learning (PjBL) motivates students to be involved in learning and problem solving through meaningful learning to help build new understanding. The implementation of the Electrical Installation Automation trainer kit in Project-Based Learning (PjBL) as an important learning model in the future must be integrated into the curriculum.

CONCLUSION

Based on the results and discussion, the implementation of the Electrical Installation Automation trainer kit in project-based learning (PjBL) can improve the quality of learning related to critical thinking, motivation, and competence of electrical engineering students. Project-based learning has succeeded in making learning more interesting, challenging, and meaningful, as well as being able to build students' motivation and critical thinking regarding the relationship between course material and learning activities. The implementation of the trainer kit in Project-Based Learning (PjBL) as an important learning model in the future must be integrated into the curriculum.

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