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Project-based Learning in The Relationship of Motivation and Critical Thinking to The Competence of Electrical Engineering Students

Subuh Isnur Haryudo[1], Ekohariadi[2], Munoto[3], Lilik Anifah[1], Fendi Achmad[1]
[1] Department of Electrical Engineering, Universitas Negeri Surabaya, Indonesia.
[2] Department of Informatics Engineering, Universitas Negeri Surabaya, Indonesia.
[3] Vocational Education, Graduate School, Universitas Negeri Surabaya, Indonesia.
[1] subuhisnur@unesa.ac.id
[2] ekohariadi@unesa.ac.id
[3] munoto@unesa.ac.id
[1]lilikanifah@unesa.ac.id
[1]fendiachmad@unesa.ac.id

Abstract: Project-based learning (PjBL) is a meaningful learning model in empowering and developing the skills of college students. PjBL will affect the motivation and critical thinking patterns of college students towards the achievement of 21st-century competencies. The purpose of this study was to determine the relationship between motivation and critical thinking on the competence of electrical through project-based learning. The research method uses a qualitative approach with an explanatory type. The research respondents were 302 final-year Electrical Engineering students from 5 universities with the competence of Electrical Installation Automation. The research instrument used a student response questionnaire type of measures of typical performance (MTP). The results of the statistical analysis test using SEM-PLS obtained a positive R-Square (indicator reliability) value of 0.961 or 96% having predictive relevance, meaning that motivation and critical thinking have a positive and significant impact on the competence of Electrical Engineering students.

Subuh Isnur Haryudo
Department of Electrical Engineering,
Universitas Negeri Surabaya, Indonesia.
subuhisnur@unesa.ac.id

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1. Introduction

Various efforts have been made to improve the outcomes of university graduates by developing learning curricula. According to Järvelä & 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. In line with Hernández & Morales (2016), professional action in the field of education in the global era is competency-based education. 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 (Ontario Ministry of Education, 2016).

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, 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 a 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 a person's growth process towards being more advanced to have the knowledge, intelligence, and ability to think (Hanna, 2013). Self-awareness, confrontation of beliefs, and emotions are self-motivation in intellectual processes that are integrated during learning (Fukuzawa, Boyd, & Cahn, 2017). Many factors can influence learning behavior, 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 behavior.

Project-based learning can be integrated into the 21st-century learning curriculum to significantly improve the quality of learning (Bell, 2010). Learning objectives are based on constructivism that supports student involvement in problem-solving situations and the process of analysis or evaluation so that the knowledge gained is more permanent (Doppelt, 2003) (Lasauskiene & Rauduvaite, 2015). In line with Brown, Collins, & Duguid (2017) PjBL supports learning theory that lies in cognition. Furthermore, Chiang and Lee (2016) problem solving with the final product displayed and presented can be done individually or in groups for a certain period together to encourage student motivation in critical thinking skills.

There are many definitions (concepts) of motivation that focus on achievement and critical thinking (Fukuzawa, Boyd, & Cahn, 2017). Increasing student competence can be done through increasing knowledge and skills while increasing motivation cannot be separated from attitudes that are influenced by social and cultural influences (Hofer, et al., 2010).

Seeing the advantages of "Project-Based Learning", this learning model can be used as the right solution to help educators in implementing Competency-based education (CBE) for Electrical Engineering students. PjBL encourages "development of collaboration skills, improvement of critical thinking, complex problem solving, transfer of learning, and positive attitude towards learning motivation" towards the competence of Electrical Engineering students.

Based on the above background, this study explores the direct and indirect relationship of motivation and critical thinking to the competence of Electrical Engineering students using PjBL. It is hoped that the development of this model can be used as an evaluation system for integrated learning models in the curriculum and help students develop mastery of content through authentic experiences.

2. Research Methodology

This research design uses a quantitative approach (Johnson & Christensen, 2017) with an explanatory type. This method was chosen to validate and test the feasibility of the measurement model of the research variables. Motivation variables use the ARCS model (Attention, Relevance, Confidence, Satisfaction) with 8 indicators (Keller, 2016) and critical thinking variables use the FRISCO model (Focus, Reason, Inference, Situation, Clarity, Overview) with 11 indicators (Ennis, 1996). The competency variable uses the Standard model (Knowledge, skill, and attitude) with 15 indicators.

Research respondents were 302 final year Electrical Engineering students with Electrical Installation Automation competencies at 5 universities in Surabaya, Indonesia. The PjBL implementation is equipped with an Electrical Installation Automation trainer kit, a learning mechanism as shown in Figure 1.

College students are faced with concrete problems, find solutions, and work on projects in teams to solve problems. The skills grown in PjBL are not only content understanding, but also skills of communication and presentation, organizational and time management, problem-solving, self-assessment

and reflection, group participation and leadership, and critical thinking.

The research was conducted from January 2019 to April 2020. Data collection techniques used questionnaires (measures of typical performance type, MTP) and interviews. Typical performance is designed to reveal the tendency of an individual's reaction or behavior in certain situations. The data analysis technique used multiple linear regression analysis assisted by Structural Equation Modeling-Partial Least Square (SEM-PLS). The analysis is carried out on the latent variable to obtain a value or measure based on the observed indicators. Latent variables based on their functions are divided into two, namely exogenous variables (motivation, critical thinking) and endogenous variables (competence).

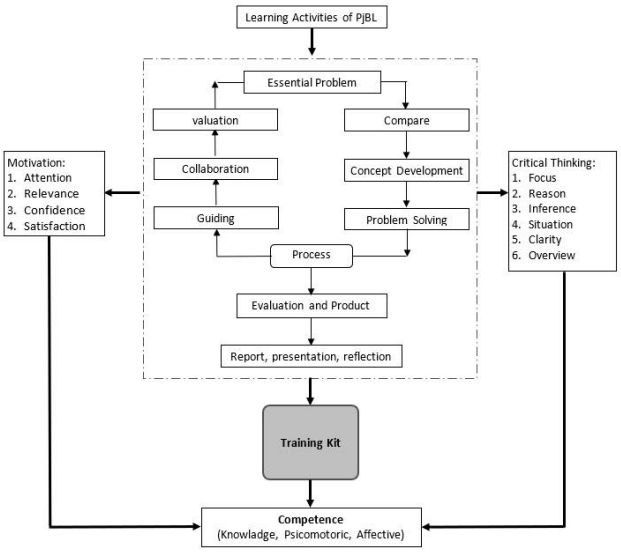

Fig 1:Project-based learning process mechanism

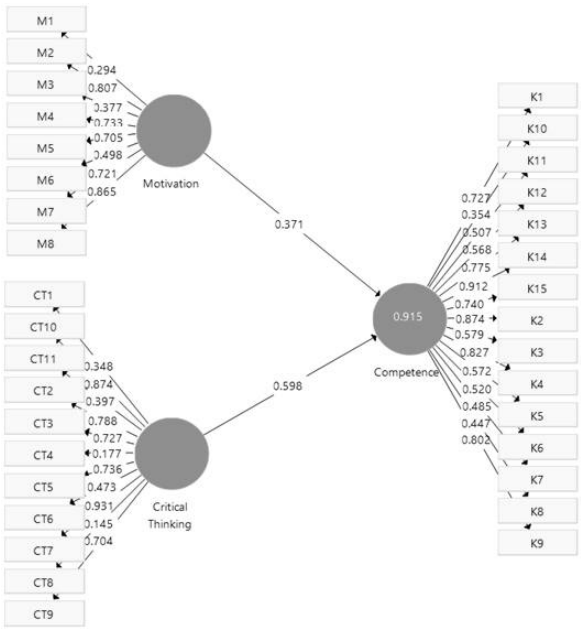

Fig.2:Construct analysis test results using Smart-PLS 3.0

3. Results and Discussion

In analyzing the relationship between motivation and critical thinking on student competencies based on project learning, it is necessary to test the measurement model and the standard estimated value of the variable. The test results of the construct analysis of the measurement model using SEM-PLS are shown in Figure 2.

The measurement model is feasible to use if it has passed the validity and construct reliability tests first. The construct validity analysis test can be done by looking at the outer loadings (factor loading) and Average Variance Extracted (AVE) values of each indicator in the construct. Invalidity testing, the indicator if it has an outer loading value $\geq$ 0.7 and Average Variance Extracted (AVE) $\geq$ 0.5 is declared valid, then the construct is declared reliable if Contract Reliability (Composite Reliability) $\geq$ 0.7 and Cronbrach's Alpha $\geq$ 0.7 (Hair, Ringle, & Ssetdt, 2011).

Table 1. The Result of Test Validity and Reliability Motivation Construct

Variable	Indicator	β	Validity	AVE	CR	CA	Statement
Motivation	M1	0.294	invalid	0.612	0.887	0.841	valid & reliable
	M2	0.844	valid				
	M3	0.377	invalid				
	M4	0.778	valid				
	M5	0.708	valid				
	M6	0.498	invalid				
	M7	0.731	valid				
	M8	0.842	valid				

The indicator test is the first construct analysis test to determine the validity of the variable before the reliability test is carried out. The results of the analysis of the motivation variable indicator analysis can be seen in table 1.

From the table, the indicators M1, M3, and M6 of the motivation variable have an outer loading value $\leq$ 0.7, which can be said to be invalid so they must be removed from the measurement model even though the AVE value is $\geq$ 0.5. Furthermore, the results of the reliability test with CR and CA values $\geq$ 0.7 can be said to be reliable.

Furthermore, the measurement of the validity analysis test is carried out on the critical thinking indicator. The results of the measurement test for validity obtained 5 indicators of critical thinking variables that must be removed, namely: CT1, CT4, CT6, CT8, and CT11. The indicator has an outer loading value ≤ 0.7 so the 5 indicators can be said to be invalid and must be removed from the construct measurement. The results of the reliability test obtained that Composite Reliability (CR) and Cronbrach's Alpha (CA) ≥ 0.7 can be said to be reliable. The following are the results of the analysis test for critical thinking indicators as shown in table 2.

Table 2. The Result of Test Validity and Reliability Critical Thinking Construct

Variable	Indicator	β	Validity	AVE	CR	CA	Statement
Critical Thinking	CT1	0.348	invalid	0.655	0.918	0.891	valid & reliable
	CT2	0.815	valid				
	CT3	0.713	valid				
	CT4	0.177	invalid				
	CT5	0.755	valid				
	CT6	0.473	invalid				
	CT7	0.950	valid				
	CT8	0.145	invalid				
	CT9	0.701	valid				
	CT10	0.891	valid				
	CT11	0.397	invalid				

The next latent variable that needs to be tested for validity is Competence. The results of the SmartPLS analysis test for the Competency variable based on table 3, the competency indicators can be said to be valid and reliable. However, 8 indicators must be deleted because they are declared invalid consisting of K3, K5, K6, K7, K8, K10, K11, and K12. The indicator must be removed from the measurement model because it does not meet the requirements for the validity of a measurement model, namely 0.7, even though the AVE value is ≥ 0.5, Composite Reliability (CR), and Cronbrach's Alpha (CA) ≥ 0.7.

Table 3. The Result of Test Validity and Reliability Competency Construct

Variable	Indicator	β	Validity	AVE	CR	CA	Statement
Competence	K1	0.710	valid	0.701	0.942	0.927	valid & reliabel
	K2	0.922	valid				
	K3	0.579	invalid				
	K4	0.880	valid				
	K5	0.572	invalid				
	K6	0.520	invalid				
	K7	0.485	invalid				
	K8	0.447	invalid				
	K9	0.868	valid				
	K10	0.354	invalid				
	K11	0.507	invalid				
	K12	0.568	invalid				
	K13	0.765	valid				
	K14	0.951	valid				
	K15	0.733	valid				

Model suitability test, after going through the analysis of the validity and reliability of the construct with the required assumptions, then the test is continued on the model suitability test (goodness of fit test) or structural model. Test the suitability of the model (goodness of fit test) according to Hair, Ringle, & Ssetdt (2011) are categorized as follows: a) GoF < 0.5 indicates that the model is categorized as weak, b) 0.5 < GoF < 0.75 indicates that the model is categorized as moderate, c) GoF > 075 indicates that the model is categorized as Good. The results of the model suitability test after removing invalid indicators or not meeting the requirements obtained R2 of 0.961. The average communalities for motivation and critical thinking indicate 0.7806 and 0.8041. Calculation results for the Goodness of Fit (GoF):

$$GoF = \sqrt{\overline{Com}\ x\ R^2}$$
$$= (0.792 \text{ x } 0.961)$$
$$= 0.872$$

The results of the GoF calculation of 0.872 can be categorized as Good, then the structure model of relationship motivation and critical thinking on competence is shown in Figure 3.

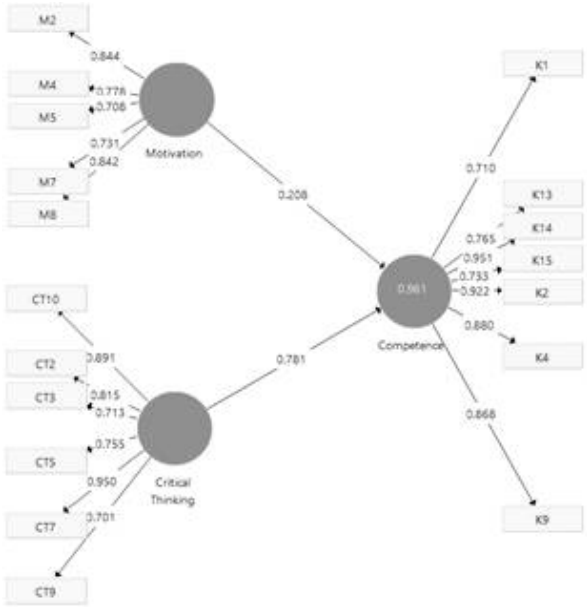

Fig. 3: Structure Model the Goodness of Fit (GoF) Test

Table 4 : The results of the discriminant validity

	Critical Thinking	Competence	Motivation
Critical Thinking	0.948		
Competence	0.810	0.978	
Motivation	0.838	0.783	0.888

To ensure that the results of the construct or latent variable have differences with other variables, a discriminant validity test is carried out using Fornell-Larcker Criterion. Table 4 shows the results of the discriminant validity test with the loading value on the intended construct having a greater value than the value of the other constructs. The hypothetical model already has a good model fit, so it is appropriate to use it to examine more deeply the relationship between motivation and critical thinking on the competence of electrical engineering students.

Based on the results of statistical analysis tests using SEM-PLS, the R-Square value (reliability indicator) of positive competence is 0.961 or 96% has predictive relevance, meaning that motivation and critical thinking have a positive and significant impact on the competence of Electrical Engineering students. This study has been discussed by Semerci (2011) that there is a relationship between motivation in the form of work attitudes and critical thinking knowledge in influencing students' academic achievement abilities to complete a job or task given during the learning process. The relationship between exogenous and endogenous variables in the constructed model is shown in table 5.

Table 5 : Test Results Between exogenous and endogenous variables

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistic (|O/STDEV|)	P Values
CRITICAL THINKING → COMPETENCE	0.781	0.780	0.042	18.533	0.000
MOTIVASI → COMPETENCE	0.208	0209	0.044	4.773	0.000

The results of the analysis of the relationship between variables (exogenous and endogenous) are shown in table 5 so that it can be explained as follows::

a. The value of Path (original sample) critical thinking on competence is positive at 0.781 with a T arithmetic value of 18,533 and a probability of 0.000. This can be interpreted as Ho is rejected or Critical Thinking has a positive and significant effect on the competence of Electrical Engineering students, this is shown by T-count ≥ T-table of 18,533 ≥ 1.96 or P-value ≤ Significant level is 0.00 ≤ 0.05.

b. The value of Path (original sample) of motivation to competence has a positive value of 0.208 with a calculated T value of 4.773 and a probability of 0.000. This can be interpreted as Ho being rejected or motivation having a positive and significant effect on the competence of Electrical Engineering students, this is shown by T-count ≥ T-table of 4.773 ≥ 1.96 or P-value ≤ Significant level is 0.00 ≤ 0.05.

Based on the test results of the analysis of the largest competency indicator (K14) with a weight of 0.951, it was stated that students were easier and more skilled in solving Electrical Installation Automation problems. This study shows that students' motivation and critical thinking will have a greater impact on student competence when mediated by a project learning model using a trainer kit. This learning support cognition by providing opportunities for real-world context and problem solving as it helps students to bring their learning into new and authentic contexts.

This shows that there is a positive correlation between motivation and critical thinking in influencing student competence. The results of the regression coefficient analysis regarding competency prediction show that critical thinking is a significant predictive instrument on competence. Motivation and critical thinking are two variables that cannot be separated to influence the success of students in developing their competencies through the completion of real projects.

3. Conclusion.

Based on the results of the analysis, it can be concluded that the mean and outer loading indicators of each variable tend to be high, this indicates that the PjBL learning process has been going well, it is proven that there is a correlation between variables that have a positive and significant effect on each other with the GoF test of 0.872 which can be categorized as Good. The development of this model can be used as an evaluation system for integrated learning models in the curriculum. Integrating PjBL into the curriculum is very important to the competence of Electrical Engineering students because it leads to critical thinking in better understanding content mastery through authentic experiences, and increasing motivation to learn.

References

[1] ATC21S (2014). Assessment and Teaching of 21st Century Skills. Official website. Available

online at: https://atc21s.org (accessed 11 February 2013)

[2] Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. The Clearing House: A Journal of Educational Strategies, Issues, and Ideas, 83(2), 39–43. https://doi.org/10.1080/00098650903505415

[3] Brown, J., Collins, A., & Duguid, P. (2017). Situated Cognition. [Web page]. Learning Theories. Retrieved from https://www.learning-theories.com/situated-cognition-brown-collins-duguid.html

[4] Chiang, C. L., & Lee, H. (2016). The Effect of Project-Based Learning on Learning Motivation and Problem-Solving Ability of Vocational High School Students. International Journal of Information and Education Technology, 6(9), 709-712, https://doi.org/10.7763/IJIET.2016.V6.779

[5] Doppelt, Y. (2003). Implementation and assessment of project based learning in a flexible environment. International Journal of Technology and Design Education, 13(1), 255-272.

[6] Ennis, R.H. (1996). Critical Thinking. London: Prentice Hall, Inc. (A Good Critical Thinking Text)

[7] Fukuzawa, S., Boyd, C., & Cahn, J. (2017). Student Motivation in Response to Problem-Based Learning, Collected Essays on Learning and Teaching, 10, 175-188. https://doi.org/10.22329/celt.v10i0.4748

[8] Hanna, E. P. (2013). A Cognitive Emotional Methodology for Critical Thinking. Advance in Applied Sociology, 3(1), 20-25. https://doi.org/10.4236/aasoci.2013.31003

[9] Hair , J.F., Ringle, C.M., & Sstedt, M. (2011). PLS-SEM: Indeed a Silver Bullet. Journal of Marketing Theory and Practice, 19:2, 139-152. https://doi.org/10.2753/MTP1069-6679190202

[10] Hernández-De-Menéndez, M., & Morales-Menendez, R. (2016). Current Trends in Competency Based Education. World Journal of Engineering and Technology, 4, 193–199. https://doi.org/10.4236/wjet.2016.43D023

[11] Hofer, J., Busch, H., Bender, M., Ming, L., & Birk Hagemeyer, B. (2010). Arousal of achievement motivation among student samples in three different cultural contexts: Self and social standards of evaluation. Journal Cross-Cultural Psychol., 41(5-6): 758-775

[12] Hutchison, D. (2015). What Works? Research Into Practice. Project-Based Learning: Drawing on Best Practices in Project Management. [PDF file]. Ministry of Education, Ontario. Retrieved from: http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/WW_BestPractices.pdf

[13] Järvelä, S., & Renninger, K. A. (2014). Designing for learning: interest, motivation, and engagement. In R.K. Sawyer (Ed), Cambridge Handbook of the Learning Sciences (2nd ed, pp. 668-685). New York: Cambridge University Press.

[14] Johnson, B., & Christensen, L. (2017). Educational Research: Quantitative, Qualitative, and Mixed Approaches. Sixth Edition: SAGE Publication, Inc.

[15] Keller, J. M. (2016). Motivation, Learning, and Technology: Applying the ARCS-V Motivation Model. Participatory Educational Research (PER), 3(2), 1–13. https://doi.org/10.17275/per.16.06.3.2

[16] Lasauskiene, J., & Rauduvaite, A. (2015). Project-Based Learning at University: Teaching Experiences of Lecturers. Procedia-Social and Behavioral Sciences, 197(February), 788–792. https://doi.org/10.1016/j.sbspro.2015.07.182

[17] Lee, D., Huh, Y., & Reigeluth, C.M. (2015). Collaboration, intragroup conflict, and social skills in project-based learning. Instructional Science, 43(5), 561-590.

[18] Montebello, M., Cope, B., Kalantzis, M., Tzirides, A. O., Haniya, S., Amina, T, & Chen, M. (2018). Critical Thinking through a Reflexive Platform. In 2018 17th International Conference on Information Technology Based

Higher Education and Training (ITHET) (pp. 1–6). IEEE.

[19] Ontario Ministry of Education. (2016). Towards defining 21st century competencies for Ontario: 21st century competencies foundation document for discussion. [PDF file]. Toronto, Ontario, Canada. Retrieved from http://www.edugains.ca/resources21CL/21stCenturyLearning/21CL_21stCenturyCompetencies.pdf

[20] Palmer, D. (2016). Motivation for Learning: An Implicit Decision-Making Process. Creative Education, 7, 2380-2388. https://dx.doi.org/10.4236/ce.2016.716229

[21] Sari, I. K. (2018). The Effect of Problem-Based Learning and Project-Based Learning on the Achievement Motivation. Jurnal Prima Edukasia, 6 (2), 129-135. http://dx.doi.org/10.21831/jpe.v6i2.17956

[22] Semerci, C. (2011). The relationships between achievement-focused motivation and critical thinking. African Journal of Business Management, 5(15), 6180-6185. https://doi.org/10.5897/AJBM10.1231

[23] Tiwari, R., Arya, R., & Bansal, M. (2017). Motivating Students for Project-based Learning for Application of Research Methodology Skills, International Journal of Applied Basic Medical Research. 7(1): S4–S7. https://doi.org/10.4103/ijabmr.IJABMR_123_17