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Analysis of Critical Thinking Aspects in the Implementation of Blended Learning Model Based on Electric Material Project

Muhammad Zainal Altim [a*], Syahrul [b] and Faisal Syafar [b]

[a] Department of Vocational and Engineering, Universitas Negeri Makassar, Indonesia.
[b] Department of Engineering, Universitas Negeri Makassar, Indonesia.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study was to determine the aspects of critical thinking in implementing a blended learning-based project model in improving learning outcomes by utilizing digital applications and platforms. The research subjects were 20 students who were interviewed and filled out a questionnaire. Based on the hypothesis, it is revealed that there is a positive impact of critical thinking aspects on learning outcomes. These aspects include interpretation, analysis, evaluation, inference, explanation, and self-regulation. Data were collected through observation, interviews and documentation. This type of research is development research (R&D) with the concept of Thiagarajan 4D theory (Define, Design, Develop, and Disseminate). Data were analyzed using descriptive statistics and qualitative analysis. With the findings: the results of statistical analysis for

**Corresponding author: Email: muhzainal.altimali@umi.ac.id;*

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the critical thinking aspects studied, all aspects influence on student learning outcomes. Based on the six aspects, the highest influence is the interpretation aspect of 82% on student learning outcomes.

Keywords: Critical thinking; blended learning based project; learning outcomes.

1. INTRODUCTION

The national education system is based on Law No. 20 of 2003. 2003 states that the success of education can contribute greatly to the achievement of overall national development goals, to realize a quality, advanced and independent society, that broad-minded and has independence. Aryawan [1] said that education must be able to produce quality, productive, skilled, independent and innovative graduates, so that they can compete in the midst of technological developments. According to Kim and Park, [2], technology-based learning has a positive influence on knowledge and critical thinking skills, self-confidence, and learning attitudes. Similarly, Muali et al, [3] said, online learning, will improve students' critical thinking skills to be better than using conventional methods.

According to Rahimah et al, [4]; Simamora [5]; and Taqwa [6]. The fact that occurs in learning, students often face challenges in understanding a concept, due to the complexity of the subject matter and the lack of complete and effective teaching materials. Students also have difficulty in problem-solving [7]. This emphasizes that the application of inappropriate learning methods can reduce student understanding. As a study conducted at the Electrical Engineering Study Program, Faculty of Engineering, Muslim University of Indonesia. From the results of observations made, it was found that students still have difficulty understanding and explaining the concept of the theory of Electrical Materials in semiconductor sub-materials, even some of them are unable to categorize the kinds of semiconductors, even though they have been taught repeatedly. Students also have difficulty both individually and in groups representing the concept of semiconductor theory based on information from other learning sources.

In line with the findings of Dwidarti et al, [8]; Astuti & Haryadi, [9]; Zahroh et al, [10]; Rosyidah et al, [11] revealed that students often face challenges in understanding and applying mathematical principles, as well as in developing mathematical reasoning skills. Lack of consistency in representing concepts has been identified as a significant factor. Romansyah & Taqwa, [12,13]. This proves that reasoning or critical thinking skills, stress, emotional intelligence, learning style, and low understanding of certain subject matter, are factors that affect student learning outcomes.

Another obstacle is a lack of learning motivation. Even though according to Andriani and Rasto [14] student learning outcomes can be improved by increasing student learning motivation. According to Rachman et al., [15] in the context of online learning, learning motivation is a key factor in improving student learning outcomes. Furthermore, another condition that was found was that students were unable to improve their abilities and evaluate their learning outcomes This statement is in line with Zapata-Cuervo et al., [16] said that the shift to online learning during the pandemic has affected students' perceptions and psychological engagement, which may affect their ability to organize their learning and evaluate their progress. Khoirudin [17] Atiyah et al. [18] said that the use of e-learning and online learning environments has been found to affect students' self-regulation abilities and learning outcomes. Linjawi & Alfadda, [19] explained that students' perceptions and attitudes towards online learning, as well as their readiness for educational modes can also affect their ability to engage in self-regulated learning and effectively evaluate student learning outcomes.

In this study there is novelty, when referring to the findings of the observation above, the aspects to be studied are aspects of interpretation, analysis, evaluation, inference, explanation, and student self-regulation. These six aspects need to be studied through research by examining aspects of students' critical thinking skills in the application of the blended learning model based on the Electrical Materials project utilizing digital applications and platforms, so that the level of students' critical thinking skills increases which affects learning outcomes.

1.1 Critical Thinking

According to Ariyana et al, [20] Critical thinking is the ability to identify, analyze, interpret, and evaluate evidence, arguments, claims and data that are widely presented through in-depth study, and be able to reflect on them. So, critical thinking is the ability to think and make decisions that have reasons and are reflective so that the truth can be believed by others [21]. The purpose of critical thinking is to try to maintain an objective position [22]. Meanwhile, the characteristics of critical thinking include the ability to identify, namely collecting and compiling the necessary information, being able to determine the main thoughts and explain the causal relationship of a question. [23].

Ennis [24] states, critical thinking is the ability to understand and evaluate arguments and claims objectively, and be able to make decisions based on valid evidence and data. Moore and Parker [25]. also explained, critical thinking is the application of careful reasoning in determining a truth through consideration of thoughts and ideas. Foresman et al, [26] define critical thinking as a systematic, reflective, critical, and creative thought process that aims to develop accurate, relevant, and evidence-based understanding. However, critical thinking must involve the use of both systems of human thought namely the fast and intuitive thinking system and the slow and rational thinking system [27].

Intellectual standards need to be trained and developed to ensure the quality of thinking about a problem, topic or situation in improving critical thinking skills, namely clarity, accuracy, relevance, logicalness, breadth, precision, significance, completeness, fairness and depth [28]. Facione [29] Facione [29] states, to determine the improvement of students' critical thinking skills, formal and systematic aspects and indicators are needed, which consist of: (1) interpretation, (2) analysis, (3) evaluation, (4) inference, (5) explanation, and (6) self-regulation. Based on the description above, it can be concluded that to achieve critical, reflective thinking and improve reasoning for an individual, several aspects of critical thinking can be formulated, namely (1) interpretation, (2) analysis, (3) evaluation, (4) inference, (5) explanation, and (6) self-regulation, because critical thinking is closely related to structured, reflective, and goal-oriented cognition, as well as abilities that can construct critical thinking in individual learners.

1.2 Learning Outcomes

Bloom [30] through Bloom's Taxonomy theory states that learning outcomes are a classification or hierarchy of categories of cognitive levels to evaluate the level of thinking ability that can be achieved by students through learning that can help, understand and design an effective learning process. The levels in Bloom's Taxonomy are (1) Understanding, (2) Remembering, (3) Applying, (4) Analyzing, (5) Synthesizing, (6) Evaluating. Gagne et al, [31] revealed that learning outcomes can be improved through effective learning planning in helping students achieve optimal learning outcomes, by providing appropriate learning techniques or effective instructional design and useful feedback for students. Erikson [32] views that learning outcomes and learning experiences greatly influence human development. In terms of learning outcomes, learning experiences are very important. Learners who experience fun and motivating learning experiences will increase their self-confidence. Maslow [33] states that each individual's needs cannot be met sequentially and must be met in certain stages. In the context of learning outcomes, this theory can identify the level of students' needs in the learning process. Furthermore, Entwistle and Ramsden [34] emphasizes the active role of learners in constructing knowledge and understanding concepts. Learning outcomes are not only determined by external factors such as subject matter, teaching methods, and learning experiences, but also influenced by internal factors such as motivation, prior knowledge and understanding, and learners' expectations of learning.

1.3 Learning Models

Helmiati [35] and Haerullah & Hasan [36] stated that the learning model is a form of learning that is framed into one unit from beginning to end and is presented characteristically by the lecturer. According to Fauzan [37] all learning models must have characteristics, namely: (1) syntax, (2) social system (3) reaction principles, (4) support system, and (5) learning impact.

1.4 Blended Learning

Christensen et al. [38] argues that blended learning is an innovation that can overhaul the

conventional education system by creating a more flexible and effective learning environment. Where, technology plays a crucial role in combining online and offline learning methods, making the learning process more personalized, interactive, and accessible anytime and anywhere. Amenduni and Ligorio [39] explain that basically, blended learning is the integration of computerized and face-to-face teaching, utilizing various components to design an effective working environment for students and teachers. Vanderkam [40] reinforces this definition by stating that blended learning is a personalized learning method through technology, which transforms general teaching into a more individual one, allowing students to adjust their learning pace and style to achieve optimal results. Simply put, blended learning is a combination of technology and human role (teachers) to improve educational outcomes. Bonk & Graham [41] adds that blended learning is a combination of two different teaching models, namely traditional face-to-face education and distance learning, in which technology plays an important role. Garrison and Vaughan [42] support this by mentioning that the essence of blended learning is a unique combination of online oral and written communication that is well integrated to produce an optimal learning experience that is relevant to educational objectives.

1.5 Project Based Learning

Krauss and Boss [43] explained that in *project-based learning* (PjBL), learners gain knowledge, skills, and understanding based on meaningful information that is provided in a directed manner. Where, learners tend to read, research, work in a team, consult, use digital technology, write, create media, and speak in public during the learning cycle, so as to increase motivation and independence in learning in solving problems, critical thinking skills and teamwork. Krajcik and Shin [44] reinforce that PjBL is a form of learning-based on constructivism, where learners gain a deeper understanding of the material when they actively build their understanding by using ideas in a real-world context. Likewise, Mahdiraji et al, [45] who explained that the implementation of project-based learning, will increase the potential, motivation and experience of learners who are involved in a project activity. In addition, it will provide direct and directed experience for students. This proves the effectiveness behind project-based learning in the scope of the teaching system.

1.6 Blended Learning-Based Project

Based on the above discussion, the notion of *project-based blended learning* refers to an instructional approach that combines traditional face-to-face teaching with *online learning* activities that integrate project-based learning principles. This approach aims to provide students with a comprehensive learning experience that emphasizes problem solving, critical thinking, and knowledge acquisition related to real-world problems. *Blended learning-based projects* allow students to apply theoretical knowledge in a practical context through projects using technology for material access, discussion, and collaborative work, as well as face-to-face meetings for mentoring, discussion, and project presentations that support the learning process. *Blended learning-based projects* prioritize flexibility, interactivity and collaboration, enriching a rich and diverse learning experience, tailoring students' individual needs through an effective combination of *online* self-directed learning and face-to-face interaction to create a learning experience while maintaining social interaction and collaboration.

The integration of *project-based learning* in a *blended learning* framework encourages students to work collaboratively, conduct research, and gain knowledge through exploration, guided by the instructor. Rahmawati & Atmojo, [46], The use of *blended learning* in a project-based learning setting has been shown to be effective in improving students' conceptual understanding and problem-solving skills in education [47]. The implementation of *blended learning* in a project-based learning scenario involves a structured approach consisting of several phases, including introduction to learning, presentation of objectives, learning techniques, and timelines. The integration of constructivist principles in *project-based blended learning* emphasizes student-centered inquiry-based learning, promoting active engagement and knowledge construction [48]. The use of *blended learning-based projects* also offers the flexibility to combine various teaching methods and technologies, such as *online* and face-to-face instruction, to create an effective and engaging learning environment [49].

2. METHODS

This research approach is descriptive qualitative and quantitative. The aim is to investigate the critical thinking aspects with the implementation

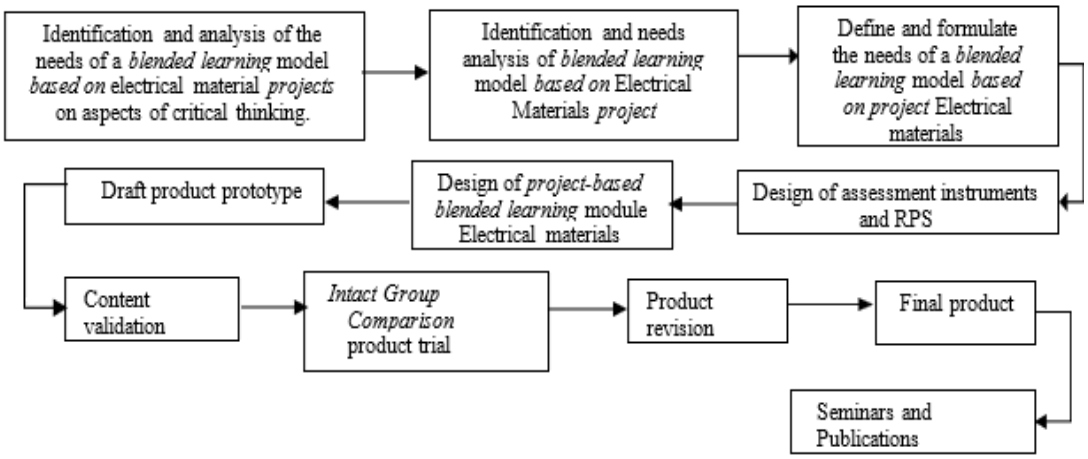

Fig. 1. R&D Research Design of 4D Stages of Blended Learning Model Based on Electric Material Project

of the blended learning model based on the Electrical Materials project utilizing digital applications and platforms such as Zoom Meeting, Youtube, Google, WhastApp, QR-Code, and Canva, in improving learning outcomes. Critical thinking aspects include interpretation, analysis, evaluation, inference, explanation, and self-regulation. Data collection was carried out through interviews and questionnaires filled out by 20 students of the Electrical Engineering Study Program at UMI. The data were analyzed qualitatively and quantitatively [50]. There are 12 instruments as data collection tools. The researcher prepared an interview grid instrument and a questionnaire sheet that had been validated by a validator and declared suitable for use. The initial hypothesis is that the aspects of critical thinking found in the review of relevant articles affect student learning outcomes. With the hypothesis formula: if t Count> t Table and significance value <0.05, then Ho is rejected and Ha is accepted. If t Count < T Table and significance value > 0.05, then Ho is accepted and Ha is rejected.

The research model chosen was Borg and Gall's (1983) Research and Development (R&D) development research with Thiagarajan's (1974) concept of 4D stages (Define, Design, Develop and Disseminate). In the define stage, researchers made a preliminary study, analyzed the needs on critical thinking aspects and formulated instructional learning objectives. In the design stage, we designed the Semester Learning Plan (SSP), blended learning module based on project and assessment instrument. At the develop stage, activities validate learning tools, assessment instruments to experts or validators before the product is tested. Meanwhile, to measure the effectiveness of the learning model, it is carried out using the Intact Group Comparison method by comparing the results of post-test scores in the class group of students who are given treatment (experimental class) and the control class group of students in other classes. Through this research will produce qualitative data and quantitative data tested with multiple linear regression to prove the initial hypothesis, that aspects of critical thinking which include: aspects of interpretation, analysis, evaluation, inference, explanation, and self-regulation, have a positive effect on student learning outcomes.

3. RESULTS

3.1 Results of the Define Stage

Table 1 shows the interview transcript data that has been grouped and reduced according to research needs.

In general, the results of observations on the six aspects of students' critical thinking were less positive. This gives an understanding that the average student's critical thinking skills are low.

3.2 Results of the Design Stage

In Table 2 is the prototype of the blended learning model based on the Electrical Materials project which is the initial draft before the develop stage, as follows:

Table 1. Summary data of the defining stage

Component	Aspects	Findings
Student interview	Interpretation	Students are less able to understand electrical material lessons given by lecturers Students are less enthusiastic while learning electrical materials Students lack confidence in their own ability to understand theoretical concepts
	Analysis	Students are less able to identify and create questions Students are less able to formulate, describe, analyze, and represent the concepts of semiconductor theory
	Evaluation	Students are less able to evaluate their own abilities Students are less able to perceive and connect the views of lecturers in providing questions Students are less able to evaluate together with friends for the results of group work.
	Inference	Students are less able to identify related semiconductor material
	Explanation	Students are less able to explain and convey the argument of semiconductor material
	Self-regulation	Students are not yet disciplined in learning Students have not been able to evaluate their learning outcomes

3.3 Results of the Develop Stage

This stage is an activity to validate the RPS, learning modules and appraisal judgment assessment instruments through FGD discussions. The validation assessment review includes: format, content, contextual and language. The validator's suggestions and input were used as the basis for researchers to make revisions. The results of revisions to the RPS and instruments were declared appropriate and feasible with very good quality. Furthermore, hypothesis testing of quantitative questionnaire data with t test or partial test to determine the relationship of aspects of interpretation (X1), analysis (X2), evaluation (X3), inference (X4), explanation (X5), and self-regulation (X6) to learning outcomes (Y). The results of validity and reliability tests on variables X1, X2, X3, X4, X5, and X6 with r Table 3 and Cronbach Alpha Table 4, resulting in all variables valid and reliable. To find out the influence between the six aspects on learning outcomes, the following stages are carried out.

3.4 Partial t Test

The t test is used to determine the relationship and influence on the aspects of interpretation (X1), analysis (X2), evaluation (X3), inference (X4), explanation (X5), and self-regulation (X6) partially on learning outcomes (Y) contained in the following Table.

Based on Table 3, the R square value is 0.860, meaning that the independent variable of interpretation aspects affects the dependent variable of student learning outcomes by 86%. From the Anova results obtained F count 110.553. The significance value is 0.00 <0.05 and it is known that t Count 10.514> 2.160 t Table, it is concluded that the interpretation aspect variable (X1) has an effect on the student learning outcomes variable (Y). Based on these results, the research hypothesis is Ho is rejected and Ha is accepted, meaning that there is an influence of the Interpretation Aspect (X1) on student learning outcomes (Y).

Based on Table 4, it shows the value with R square 0.750, meaning that the independent variable of the analysis aspect affects the dependent variable of student learning outcomes by 75%. From the Anova results obtained F count 53.983. The significance value is 0.00 <0.05 and it is known that t Count 7.347> 2.160 t Table, it is concluded that the analysis aspect variable (X2) has an effect on the student learning outcomes variable (Y). Based on these results, the research hypothesis is Ho is rejected and Ha is accepted, meaning that there is an influence of the Analysis Aspect (X2) on student learning outcomes (Y).

Based on Table 5, the relationship value R is 0.791 with R square 0.626, meaning that the independent variable of evaluation aspects affects the dependent variable of student learning outcomes by 62%. From the Anova results obtained F count 30.163. The significance value is 0.00 <0.05 and it is known that tCount

5.492> 2.160 t Table, it is concluded that the evaluation aspect variable (X3) has an effect on the student learning outcomes variable (Y). Based on these results, the research hypothesis is Ho is rejected and Ha is accepted, meaning that there is an influence of the Evaluation Aspect (X3) on student learning outcomes (Y).

Based on Table 6, the R square value is 0.655, meaning that the independent variable of inference aspects affects the dependent variable of student learning outcomes by 65%. From the Anova results obtained F count 34.237. The significance value is 0.00 <0.05 and it is known that t Count 5.851> 2.160 t Table, it is concluded that the inference aspect variable (X4) has an effect on the student learning outcomes variable (Y). Based on these results, the research hypothesis is Ho is rejected and Ha is accepted, meaning that there is an influence of inference aspects (X4) on student learning outcomes.

Table 2. Summary of prototype components

No.	Prototype of Blended Learning Model Based on Electric Material Project	Description
1	Model objectives	To assess the learning of Electrical Materials for students in improving learning outcomes through a project-based blended learning model.
2	Model characteristics	Integration of Electrical Materials lessons with project-based blended learning model Syntax created project flow
3	Components of the blended learning model based on the Electrical Materials project	Learning tools include: RPS, blended learning teaching module based on Electric Material project. Syntax Assessment instruments in the form of test and non-test questions (questionnaire) Learning outcome assessment methods
4	Model syntax	Define the fundamental question Design a project plan Develop a schedule Project implementation Testing project results Evaluation
5	Model instrument	Needs analysis instrument Observation instrument for semester learning plan (RPS) Observation instrument for lecturers' ability to manage blended learning-based on projects Design instrument for blended learning model based on project Project-based blended learning syntax instrument Student activity observation instrument for blended learning-based project learning Observation instrument for lecturer activities in blended learning-based on projects Observation instrument for the implementation of project-based blended learning Questionnaire instrument for lecturer response to blended learning-based on projects Student response questionnaire instrument Learning outcome instruments Student critical thinking questionnaire instrument

Table 3. Model summary aspect interpretation (X1)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,927[a]	,860	,852	2,57109

a. Predictors: (constant), interpretation

Table 4. Model summary aspect analysis (X2)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,866[a]	,750	,736	3,43593

a. Predictors: (constant), analysis

Table 5. Model summary aspect evaluation (X3)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,791a	,626	,606	4,20049

a. Predictors: (constant), evaluation

Table 6. Model summary aspect inference (X4)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,810[a]	,655	,636	4,03338

a. Predictors: (constant), inference

Table 7. Model summary explanatory aspects (X5)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,716a	,513	,485	4,79727

a. Predictors: (constant), explanation

Table 8. Model summary aspects of self-regulation (X6)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,603a	,363	,328	5,48347

a. Predictors: (constant), self-regulation

Table 9. Model Summary Relationship between Critical Thinking Aspects and Learning Outcomes

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,950a	,902	,857	2,52739

a. Predictors: (constant), interpretation, analysis, evaluation

Based on Table 7, the R square value is 0.513, meaning that the independent variable of the explanation aspect affects the dependent variable of student learning outcomes by 51%. From the Anova results obtained F count 18.926. The significance value is 0.00 <0.05 and it is known that t Count 4.350> 2.160 t Table, it is concluded that the explanation aspect variable (X5) has an effect on the student learning outcomes variable (Y). Based on these results, the research hypothesis is Ho is rejected and Ha is accepted, meaning that there is an influence of the explanation aspect (X5) on student learning outcomes.

Based on Table 8, it shows the R square value of 0.363, meaning that the independent variable of self-regulation aspects affects the dependent variable of student learning outcomes by 36%. From the Anova results obtained F count 10.262. The significance value is 0.005 <0.05 and it is known that t Count 3.203> 2.160 t Table, it is concluded that the variable aspect of self-regulation (X6) affects the student learning outcomes variable (Y). Based on these results, the research hypothesis is Ho is rejected and Ha is accepted, meaning that there is an influence of self-regulation aspects (X6) on student learning outcomes (Y).

3.5 Simultaneous F Test

The F test is used to determine the relationship and influence of aspects of interpretation (X1), analysis (X2), evaluation (X3), inference (X4), explanation (X5), and self-regulation (X6) simultaneously on student learning outcomes (Y) as outlined in the following Table 9.

Based on the Anova results and the basis for decision making that has been determined, it is known that the significance value is 0.00 <0.05 and the calculated F value is 20.006> 2.85 F Table, it is concluded that there is an influence for the aspects of Interpretation (X1), Analysis (X2), Evaluation (X3), Inference (X4), Explanation (X5) and Self-regulation (X6) simultaneously affect student learning outcomes (Y). Based on these results, the research hypothesis is Ho is rejected and Ha is accepted, meaning that there is an effect of critical thinking aspects simultaneously on student learning outcomes. Based on Table 7, it is known that the R Square value is 0.902, this shows that the contribution of the influence of X1, X2, X3, X4, X5, X6 on Y is 90%, while the remaining 10% is the contribution of other variables not studied.

4. DISCUSSION

Based on the results of the regression analysis above, it can be seen that the Interpretation aspect has the highest influence on student learning outcomes by 82% when compared to the other five aspects. For the results of the F test simultaneously, the effect of critical thinking aspects is 90% on student learning outcomes. This shows that to improve student learning outcomes it is necessary to support critical thinking skills on condition that they must have the ability to interpret, analyze and evaluate. Here students must have the ability to understand and express various experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or criteria, starting from categorization skills, and interpreting. Then be able to identify inferential relationships between statements, questions, concepts, descriptions, or other forms of representation intended to express beliefs, judgments, experiences, reasons, information, or opinions. In addition, they are able to assess the credibility of statements or other representations of perceptions, experiences, situations, judgments, beliefs, or opinions and assess the logical strength of the actual inferential relationship between statements, descriptions, questions, or other forms of representation. For this reason, it is hoped that future researchers will be able to review several other aspects of critical thinking from the studies that have been conducted.

5. CONCLUSION

In the application of the blended learning model based on the Electrical Materials project utilizing digital applications and platforms in the form of Zoom Meeting, Youtube, Google, WhastApp, QR-Code, and Canva, which are reviewed from students' critical thinking skills, there is an increase in learning outcomes. Thus, the application of the blended learning model based on the Electrical Materials project through the results of the investigation on the critical thinking aspects studied in students, is categorized as successful and very positive to improve student learning outcomes. The blended learning model based on the Electrical Materials project developed is also in accordance with the learning objectives set.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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