Meta-analysis of the Aspects of Student Thinking Creativity in Learning Project Based Learning (PjBL) to Improve Learning Outcomes

ABSTRACT

The objective of this study was to examine elements of student cognitive ingenuity developed through Project-based Learning (PjBL) to enhance educational achievements. The research participants consisted of 22 students enrolled in the Electrical Engineering Study Program. The basic hypothesis posits that the presence of creative thinking elements has a beneficial impact on enhancing students' learning results. The key aspects encompassed are fluidity, flexibility, originality, and elaboration. The data were gathered using questionnaire-based observation, utilizing instruments that have been validated by specialists. This research falls under the category of Research and Development (R&D) and follows the Thiagarajan 4D paradigm, which involves defining, designing, developing, and disseminating. The data analysis was conducted using descriptive statistics and the PjBL learning effectiveness test, with a comparison made between intact groups. Analysis reveals that all four aspects examined have a significant impact on enhancing learning outcomes. Nevertheless, the most significant impact is observed in the domain of fluency when it comes to learning outcomes. The efficacy of PjBL learning in enhancing learning outcomes in Energy Conversion courses was found to be significantly superior to that of conventional learning approaches. In the upcoming study, it is advised to investigate and expand upon four unexplored facets of creative thinking.

Keywords: needs analysis, thinking creativity, project based learning, learning outcomes.

1. INTRODUCTION

Education should aim to cultivate individuals with a strong capacity for creativity, as creativity is a catalyst for innovation. The cultivation of creativity can be fostered through the use of educational practices that enhance students' active engagement during the learning process. There is a significant level of engagement between the lecturer and students, facilitated by the use of diverse learning methodologies that enable students to construct knowledge autonomously. [1](Cossu et al., 2024)asserted that students' cognitive creativity significantly impacts their ability to attain a satisfactory final grade in the course. Hence, (Segundo-Marcos et al., 2023) proposed investigating classroom methodology as a mediating element in fostering the growth of creative thinking.

PjBL, or Project-based Learning, offers significant advantages in the realm of education by efficiently fostering students' self-directed learning, practical implementation, and innovative capacities(Tong et al., 2020). According to(Craig & Marshall, 2019), students who learn through Project-based Learning (PjBL) in a group have similar levels of academic achievement compared to those who learn traditionally. (Puspitarini & Hanif, 2019)found that instructors who rely on the lecture technique and book learning resources fail to capture students' attention, resulting in a lack of understanding of the topic and a drop in student learning motivation. Traditional education contributes to pupils' challenges in comprehending teachings, lack of motivation, and less creativity. According to(Amiruddin et al., 2018), the utilization of the PjBL learning paradigm resulted in a significant 59.8% increase in the employability of mechanical engineering vocational students.

There is empirical evidence that PjBL (Project-Based Learning) enhances student learning outcomes, as demonstrated by studies conducted by (Nurhadiyati et al., 2021; Syakur et al., 2020). According to(Ardianti et al., 2017), the implementation of the PjBL strategy in science edutainment can greatly impact student creativity. According to(Ratnasari et al., 2018), using PjBL (Project-based Learning) in mathematics lectures instead of conventional models has a more favourable impact on students' abilities. According to reports, PjBL education has the potential to enhance creativity and foster the development of cooperation abilities among instructors. (Tsybulsky & Muchnik-Rozanov, 2019)suggests that the implications of PjBL have a positive impact on the professional literature about team teaching of science courses. This can motivate educators to include team teaching in their

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practice, using student-centred techniques. (Andriyani & Anam, 2022)have confirmed that there is a positive correlation between PjBL learning and collaborative skills. The PjBL learning paradigm is highly recommended for implementation in STEM education to enhance its effectiveness(Diana et al., 2021).
According to(Ariyanto &Sutama, 2022), PjBL learning has been found to enhance students' independence. The PjBL model has the capacity to facilitate problem-solving activities in the field of Geography(Setyaningsih & Rahman, 2022). The ability to solve problems in this context leads to the expansion of knowledge and the confirmation of theories related to constructivist learning and design thinking (Tsai et al., 2023). (Marnewick, 2023)research indicates that Project-based Learning (PjBL) and the iterative characteristics of agile methodology are mutually supportive when it comes to creating artefacts. Therefore, it may be inferred that PjBL learning yields genuine assessment outcomes, enhances creativity, effectively resolves problems, and enhances student learning achievements. This study seeks to examine how lecturers actively involve students in project-based learning on Energy Conversion in the field of Electrical Engineering, with the specific objective of investigating the impact of students' creative thinking on their learning results.

1.1 Creativity Thinking

Creativity refers to the cognitive and spiritual capacity that enables someone to generate anything valuable, structured, aesthetically pleasing, or significant, seemingly out of nothing (Gerard, 2016). The process of creative thought can elicit a range of emotions, including both natural and innate feelings of joy or frustration. (Hutagalung & Situmorang, 2008) assert that creative thinking can be achieved by: (1) actively seeking novel ideas or concepts through the synthesis of existing knowledge, (2) being attentive to unexpected phenomena, and (3) promptly acting upon ideas that elicit amusement or joy. Creativity is an innate instinct that emerges from birth, yet it cannot progress alone. It necessitates external stimulation from the surrounding environment (Firmansyah & Roosmawarni, 2019). Creative thinking can be defined as the capacity of humans to generate novel ideas, possess a versatile and receptive mindset towards diverse concepts, exhibit genuine or innovative thoughts, and effectively engage in problem-solving by expanding and refining their ideas. According to(Silver, 1997), this creative thinking skill is classified as necessitating multiple components, including fluency, adaptability, and novelty.
Based on the analysis of the aforementioned papers and Silver's assertion, it can be inferred that creative individuals possess cognitive processes characterized by fluency, originality, flexibility, and elaboration. According to (Mulyadi, 2011), creativity refers to the capacity to generate novel ideas and innovative approaches to problem-solving and identifying opportunities. (Helmiati, 2012) argues that fostering student creativity in expressing and generating new ideas is crucial for their self-development, particularly when using a constructivist approach to learning.

1.2 Project Based Learning (PjBL)

PjBL, as defined by Minister of Education and Culture Number 4 of 2020, is a learning approach that primarily relies on constructivist learning theories. Constructivism refers to the process of generative learning, which involves constructing meaning from acquired knowledge (Dangnga & Muis, 2015). (Piaget, 1999) asserts that the combination of progressive accommodation and mutual assimilation of schemes results in intelligence with a learning process that should not be viewed as solely experimental or deductive. Instead, it involves both experience and mental construction simultaneously. The learning process strategy aims to narrow the disparity between graduates' abilities and society's expectations. This is achieved by using a project-based learning process that focuses on building practical skills relevant to the professional world (Susiloworo, 2019).
(Daryanto & Rahardjo, 2012)propose that the PjBL learning model exhibits the following characteristics: (1) students engage in decision-making regarding a framework, (2) students are presented with problems or challenges, (3) students devise processes to determine solutions to the presented problems or challenges, (4) students collaboratively assume responsibility for accessing and managing information to solve problems, (5) the evaluation process is conducted continuously, (6) students periodically reflect on the activities they have undertaken, (7) the final outcome of the learning activities is assessed qualitatively, and (8) the learning environment is highly tolerant of errors and modifications.

2. METHODOLOGY

This research methodology employs a descriptive quantitative approach. The objective of this study is to examine how several elements of student creative thinking, such as fluency, originality, flexibility, and elaboration, can impact student learning outcomes in the Electrical Engineering Study Program at

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the Universitas Muslim Indonesia Makassar campus. Information was gathered via questionnaires completed by a total of 22 students. There are two assessment instruments that are used as data collection tools: the needs analysis instrument and the PjBL learning trial results instrument. Prior to utilization, specialists conducted content validation through focus group discussions (FGD) and confirmed its viability.

Data gathering was initially conducted to ascertain the requirements of student learning models created in PjBL. Students concurrently completed the questionnaire sheet, albeit in disparate sites or locations. The questionnaire grid comprises four dimensions or features that have been identified in this investigation. The acquired initial data on the four aspects were subsequently subjected to quantitative statistical analysis. The selected research model was the (Aka, 2019)Research and Development (R&D) framework, which incorporates (Thiagarajan et al., 1974)notion of 4D stages (define, design, develop, and disseminate) as illustrated in Figure 1.

During the define stage, researchers conducted an initial study, examined the requirements of the four dimensions of creative thinking, and developed instructional learning goals. The design step involves the creation of Semester Implementation Plan (SSP) devices, instructional modules, and evaluation instruments. During the development stage, activities involve the validation of learning tools and assessment instruments by specialists prior to their usage in data collection. Meanwhile, the intact group comparison approach is employed to assess the efficacy of PjBL learning products. This method involves comparing the learning outcomes of the control class group with the experimental class group, which receives the PjBL learning treatment.

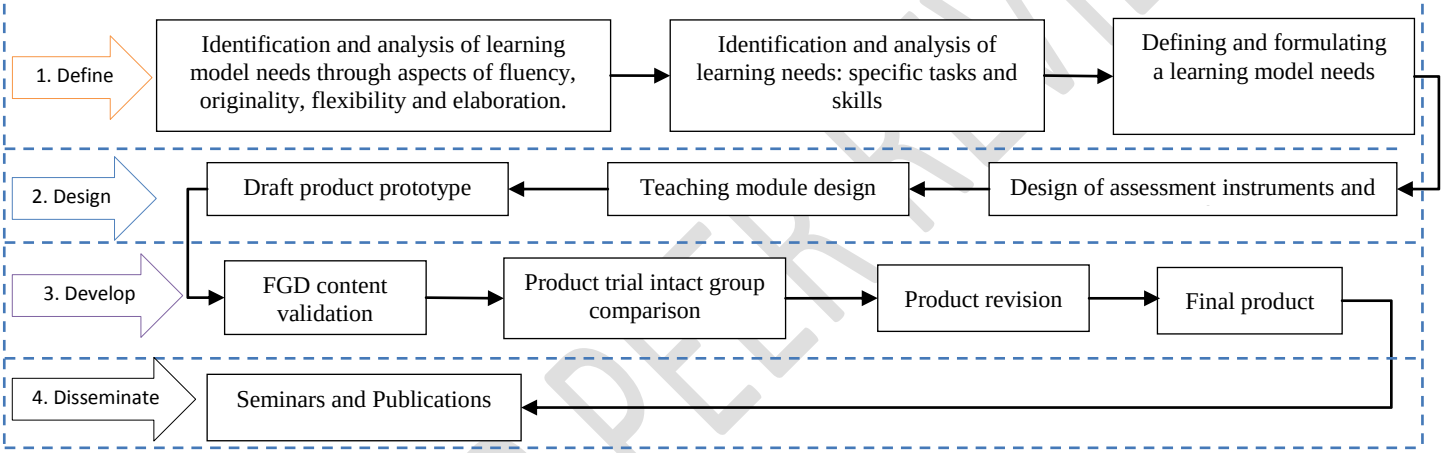

Fig.1. R&D Research Design 4D Stages

3. RESULT AND DISCUSSION

3.1 Result

3.1.1 Define Stage (Needs Analysis)

At this stage identify and analyse the specific tasks and skills of students through questionnaires in the aspects of fluency, originality, flexibility and elaboration. This data is presented for the dimensions of aspects that have a significant effect on thinking creativity presented in Table 1.

Table 1. Summary of Questionnaire Results on Student Thinking Creativity Aspects

No	The Problems	Score	
		appropriate	inappropriate
A	**Flexibility Aspect**		
1	Not yet able to provide interpretation of pictures, stories, or problem tasks	73%	27%
2	An interesting presentation of the material taught by the lecturer is needed	19%	81%
3	Currently unable to take into account the perspectives of peers with divergent attitudes on challenging assignments	28%	71%
4	Currently lacking the ability to independently solve difficulties on challenging tasks	26.4%	63.6%
B	**Original Aspect**		
5	Currently unable to independently accomplish things using a unique thought process that differs from that of friends	90.9%	9.1%

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C	Elaboration Aspect		
6	Currently lacking the capacity to search for profound significance in the responses to inquiries	81.8%	19.2%
7	Challenges in generating novel concepts acquired from peers	90.9%	9.1%
8	Did not make a sincere effort to thoroughly reevaluate one's own responses to assignment inquiries	81.8%	18.2%

Table 1 indicates that the attributes of flexibility, originality, and elaboration exhibit issues with elevated mean scores. However, the table does not display any issues related to fluency, indicating that there are no challenges in this regard. Table 2 presents the findings from the analysis of the Semester Learning Plan (RPS) text and teaching modules.

Table 2. Summary of Observation of SSP and Teaching Module

No	Components and Issues	Findings
A	**change of study plan**	
1	The appropriateness of the CPMK applied to the curriculum is contingent upon its relevance to the instructional content.	inappropriate
2	Appropriateness of learning indicators in relation to fundamental competencies	Tidak sesuai
B	**Teaching Module**	
3	Alignment of material content with competency targets	Tidak sesuai

Table 2 indicates that the RPS and instructional modules are unsuitable based on the findings. It can be inferred that teaching tools for Energy Conversion material should be developed to align with specific learning requirements.

3.1.2 Design Stage

During this phase, a preliminary version of the assessment instrument, RPS, and module was created. Prior to conducting tests on this learning tool, specialists perform content validation.
At this point, the learning aids should be validated by experts through FGD (Focus Group Discussion) to assess their format, content, contextual relevance, and language. FGD talks are conducted to validate the format, content, context, and language of the information. The assessment of the device's revision concluded that it is suitable and achievable, demonstrating excellent quality. The upcoming activity entails the evaluation of educational materials through the following sequential procedures.

3.1.3 Develop Stage

At this point, the learning aids should be validated by experts through FGD (Focus Group Discussion) to assess their format, content, contextual relevance, and language. FGD talks are conducted to validate the format, content, context, and language of the information. The assessment of the device's revision concluded that it is suitable and achievable, demonstrating excellent quality. The upcoming activity entails the evaluation of educational materials through the following sequential procedures:

- Hypothesis testing
  Hypothesis testing is being conducted on the questionnaire data using t-tests or partial tests to establish the correlation between fluency aspects (X1: fluency, X2: originality, X3: flexibility, X4: elaboration) and learning outcomes (Y). Validity and reliability tests were conducted on variables X1, X2, X3, and X4. The findings showed a correlation coefficient (r) of 0.413 and a Cronbach Alpha value of more than 0.6. As a consequence, 23 variables were determined to be both valid and reliable. To ascertain the impact of four factors on enhancing learning outcomes at different stages:
- Partial t-test
  The table below summarizes the partial impact of fluency (X1), originality (X2), flexibility (X3), and elaboration (X4) on the enhancement of learning outcomes (Y).

Table 3. Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
X1	Regression	360,646	1	360,646	72,023	,000b
X2 X3	Regression	134,472	1	134,472	8,242	,009b
X4	Regression	163,018	1	163,018	10,949	,004b

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Regression	159,753	1	159,753	10,613	,004b

Table 3 displays the statistical significance of the 4 variables, all of which have a value less than 0.05. Consequently, each of the 4 variables has a notable impact on enhancing learning results.

Table 4. Model Summary X1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
X1	,885[a]	,783	,772	2,23772
X2	,540[a]	,292	,256	4,03932
X3	,595[a]	,354	,321	3,85860
X4	,589[a]	,347	,314	3,87970

Table 4 indicates that X1 has the biggest partial effect on increasing learning outcomes, accounting for 78.3% of the variation as measured by R Square.

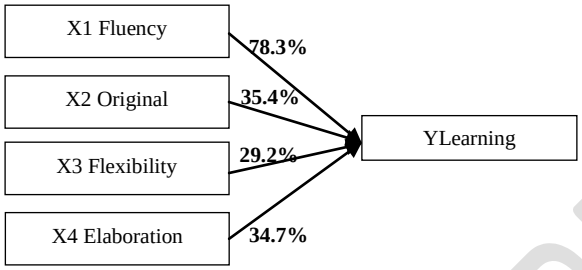

Figure 2. Illustrates the relationship between 4 aspects of path analysis and learning outcomes.

- Simultaneous F test
  The F test is employed to ascertain the concurrent link and impact of fluency (X1), originality (X2), flexibility (X3), and elaboration (X4) on learning outcomes (Y), as illustrated in the table below:

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,938a	,880	,852	1,80467

a. Predictors: (Constant), X1, X2, X3, X4

According to the R Square value in Table 5, it indicates that the combined impact of X1, X2, X3, and X4 on enhancing learning outcomes is 88%.

- Learning Outcome Test
  The efficacy of PjBL learning products is assessed using the intact group comparison approach, specifically by comparing the learning outcomes in the experimental class group with those in the control class using the Ngain formula.

Table 6. NGain Data Normality Test Results

		Kolmogorov-Smirnova			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
D	Experimental Class	,190	22	,038	,888	22	,018
	Control Class	,160	22	,146	,944	22	,239

Based on the findings in Table 6, the significance value is greater than 0.05. Therefore, it can be concluded that both the experimental class and control class exhibit normally distributed data.

Table 7. Ngain_Percent Class Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Ngain_Percent	= Experimental Class	22	62,3658	14,93011	3,18311
	= Control Class	22	31,3958	14,78829	3,15287

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Table 8. Interpretation List (%)

Percentage (%)	Interpretation
< 40	Ineffective
40 - 55	Not as efficient
56 - 75	Highly efficient
> 76	Efficient

(Source: Hake, R.R, 1999)

According to the data in Table 7, the mean value for the experimental class was 62.36%, whereas the control class had an average of 31.39%. According to the interpretation list table on effectiveness, the PjBL learning model in the experimental class falls into the moderately effective category. The usual strategy is considered ineffective for the control class. Descriptive data indicate that there are disparities in the efficacy of PjBL model learning compared to conventional method learning in enhancing student learning outcomes.

3.2 Discussion

The aspects of creative thinking have an impact on student learning outcomes. In this thought process, children possess elements of creativity, including the ability to generate novel ideas, think fluently, and effectively solve issues. Authentic student thinking is a cognitive process that aims to generate novel ideas through issue comprehension, hypothesis formulation, evidence-based inquiry, and the creation of tangible outcomes. Effective teaching requires the presence of innovative instructors who possess advanced pedagogical skills. Lecturers who lack originality may fail to engage pupils, resulting in reduced enthusiasm and limited comprehension of the subject matter.

The effectiveness of student learning outcomes through PjBL learning is well acknowledged. These findings indicate that the PjBL model has a substantial influence on learning outcomes by fostering the development of students' creative thinking abilities. In order to enhance student learning results, innovative educators must possess the ability to devise effective tactics and carry out ongoing assessments.

4. CONCLUSION

The success of PjBL learning is marked by the increasing student learning outcomes. The application of this PjBL learning model is effective enough to be applied in Energy Conversion courses. This PjBL has advantages in improving students' creative thinking or creativity in thinking and solving problems, where the improvement of this ability is in accordance with the competencies expected in modern concept learning. The success of PjBL learning is largely determined by the role of lecturers as facilitators and lecturers who have strategies and techniques for implementing PjBL. It is suggested that further studies can develop by exploring 4 aspects of thinking creativity that have not been studied in this study.

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