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PROJECT-BASED LEARNING AND PROBLEM-BASED LEARNING MODELS IN CRITICAL AND CREATIVE STUDENTS

A. Suradika[1], H. I. Dewi*[2], M. I. Nasution[3]

[1]Professor, Master of Educational Technology, Universitas Muhammadiyah Jakarta, Indonesia
[2]Associate Professor, Master of Educational Technology, Universitas Muhammadiyah Jakarta, Indonesia
[3]Student, Master of Educational Technology, Universitas Muhammadiyah Jakarta, Indonesia

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ABSTRACT

This research is experimental research with a 2 x 2 factorial design involving students in the critical and creative categories. Data collection used a description test instrument. Data were analyzed inferentially by hypothesis testing ANACOVA comparison. Problem-Based Learning (PBL) directs students to learn, directs individual and group investigations, generates and performs work, and assesses the problem-solving process. While the syntaxes for Project-Based Learning (PjBL) are starting learning with essential questions, designing a plan for the project, creating the schedule, monitoring students and project progress, assessing the outcome, and evaluating. This study concludes that there is no difference in chemistry learning outcomes between students who are taught using PBL and PjBL, and students who are critical and creative. For syntax, there are similarities in the activities of critical and creative students, at the PjBL stage, in designing a project and evaluating a product, and at the PBL stage, in guiding individual investigations and developing and presenting results.

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Keywords: creative thinking; critical thinking; learning outcomes; PjBL; PBL

INTRODUCTION

Chemistry is one of the subjects with a level of high difficulty. It has many draft complexes for understanding activities related to reactions, calculations, and abstract concepts. Students also experience difficulty in chemistry because the formula for answering questions is difficult to remember. Difficulty in studying chemistry results in low students' learning outcomes.

In the 2013 curriculum, creativity and critical are important factors in learning including chemistry learning. Based on student learning outcomes, out of 30 students, 10 students scored more than 78 (33.33%), and 20 students scored less than 78 (66.67%). As a comparison, the minimum mastery criteria for chemistry is 78. From these data, 66.67% of students do not pass the minimum criteria. Thus, research is needed that focuses on the creativity and critical level of students in the learning process to obtain optimal learning outcomes in chemistry learning. In a learning theory known as Reigeluth's (2013) prescriptive theory, has the view that by paying attention to the learning conditions and learning objectives, suggestions can be given on which methods are suitable for the learning process. There are two types of learning models, namely PjBL and PBL. For this reason, this study will conduct trials by manipulating 2 variables, namely creativity and critical variables and learning model variables to obtain maximum results.

When the teacher asks the same question, students can answer correctly. However, students have difficulty answering and explaining the material when the teacher asks different questions. As a result, students find it difficult to engage in learning because education focuses more on im-

*Correspondence Address
E-mail: h.indiradewi@umj.ac.id

parting than applying skills. This possibility causes a gap between students in school and what they need for work (Holmes, 2012).

Based on the description above, the following problems can be formulated: (1) Is there a difference in the results of chemistry learning for students who are taught by PBL and PjBL? If so, which learning model gives a higher chemistry learning result? (2) Is there an interaction between students' thinking abilities and learning models that can give different learning outcomes? (3) For students with critical thinking skills, which learning model will provide higher learning outcomes, the PjBL or PBL models? (4) For students with creative thinking skills, which learning model will provide higher learning outcomes, the PjBL or PBL models?

In the world of education, Indonesia is still left behind compared with other countries in the world, especially in ASEAN (Rahabav, 2016). Based on the PISA (Program of International Student Assessment), Indonesia occupies a ranking 62nd out of 70 countries in literacy. Indonesian science gets a value of 402, far away from the PISA average value. Low-quality education is often associated with a less creative learning process involving students actively and applying student-centered learning to develop higher-order thinking skills (HOTS). Leow and Neo (2014) state that teacher-centered learning eemphasizes the ability to memorize the theory so students have no capability for applying learning in daily life. In overcoming these problems, a learning paradigm is required to increase students' interest, introduce them to chemistry, give them the opportunity to solve real-world problems, and develop their skills. PBL and PjBL are interesting methods to achieve this goal.

PBL uses problems as the main focus and has an active teaching strategy for students, assisting them in developing skills for thinking and solving problems collaboratively (Kauchak & Eggen, 2012; Rusmono 2017; Silva, 2018). Problems encourage students to share knowledge, negotiate alternative ideas, search for information, and build arguments to support solutions that have been established (Sawyer, 2014). PBL can improve critical thinking skills (Marzuki & Basariah, 2017; Silva et al., 2018). Students are more motivated to be involved in the learning process using the PBL model, which improves their critical thinking skills (Setyosari & Sumarmi, 2017).

The initial stage of PBL is to orient themselves to challenges. They are encouraged to do various drafts of the problem formulation. The problems used in the PBL model should be designed to improve students' knowledge, skills, behavior, and attitudes (Barrett, 2013). At the planning stage, the teacher helps every group participant choose a project theme, create a project schedule, and collect related theories. Students work in groups to complete design projects (Bender, 2012). During the implementation and presentation stages, students create three different types of projects, such as slime, jelly, and ice cream. At the assessment stage, students present the results of their projects and evaluate their friends. The teacher gives feedback, and then students reflect and improve their projects (Bender, 2012; Kean & Kwe, 2014). Then, all stages of the learning process are done. After the learning process, students are divided into several groups and are allowed to communicate with each other, exchange views, and contribute their own opinions. In this working group, students can improve their creative thinking skills (Ulger & Imer, 2013). Students collect relevant materials for explanation and problem-solving strategies in self-inquiry.

At this stage, they contribute their ideas in order to find a solution. The next stage is the presentation of work results, where students learn about the plan and make reports to be presented to classmates. Through this practice, it is hoped that other students can develop the ideas proposed with their own. The final stage is the assessment of solutions to the problem. Susanto (2013) states that intelligence, readiness, or maturity to engage in learning activities, enthusiasm, presentation of the theory of learning models offered by teachers, and a fun learning environment can affect student learning outcomes. According to Alder and Milne (1997) in Fatirul (2020), PBL is an approach that focuses on identifying problems and building problem analysis frameworks (Silva, 2018).

In PjBL, according to Sulaeman (2020), students have the freedom to conceptualize themes or learning points. This is a learning approach that involves students in creating meaningful project products for daily life (Sawyer, 2005; Brundiers & Wiek, 2013). Applying project-based learning (PjBL) increases students' creativity, independence, involvement, self-confidence, reasoning, and critical and analytical thinking.

Krajcik and Shin (2014) confirm that superiority in PjBL is a significant problem, focusing on the learning goal, engagement in activity, collaboration among students, and between students and instructors, and use of technology for creating real results. There are some principles in the PjBL model: (1) students are the center of learning; (2) this model increases students' creativity, (3) this model increases challenging and exciting atmosphere in class; (4) this model includes values, aesthetics, ethics, healthy reasoning, and kinesthetic; (5) this model needs longer duration to share experience in diverse learning.

According to Yusriani et al. (2020), challenges faced by teachers with the PjBL model include time allocations outside class. With limited availability of tools or infrastructure and unfamiliarity with this model, the teacher still cannot choose appropriate projects with this learning model. High expenses, lack of training, no existence of LKPD-based projects, lack of students' freedom, and long assessment procedures are also obstacles. Through PjBL, students improve their skills in problem-solving, critical and creative thinking, communication, collaboration, change adaptation, and evaluation (Khoiri et al., 2013). The PBL model utilizes real-world situations to inspire students (Farhan & Retnawati, 2014). PBL emphasizes problem-solving and considers experience, meanwhile, PjBL directs students to obtain new skills.

Several related studies related to students' perceptions of PjBL find that group work in PjBL can increase students' critical thinking, engage students, offer a good learning atmosphere, and train students' self-control (Hall et al., 2012; Yang et al., 2012; Poonpon, 2017; Assaf, 2018; Belagra & Draoui, 2018; Vogler et al., 2018). George Lucas Educational Foundation (2014) explains that PjBL and PBL have 5 (five) equations: 1) start learning by identifying problems or situations that lead to context learning; 2) emphasize the application of the right content and skills; 3) build 21st-century skills; 4) encourage students to be more independent, 5) need longer time compared to conventional learning.

Information and Communications Technology (ICT) develops rapidly, giving opportunities for innovations in various fields, including education. As a result, competition is more open and stricter globally to increase life skills in this era. Dwyer et al. (2014) expand 21st learning frameworks consisting top three skills as results of the learning process: (1) life and career skills, (2) learning and innovation skills, and (3) information and technology skills. For learning and innovation skills, the learning process at school must equip students with four skills, namely, creativity, critical thinking, collaboration, and communication called 4C. In these 4C skills, bloom's taxonomy is the center of higher-order thinking skills (HOTSs).

According to National Council for Excellence in Critical Thinking (NCECT, 2017), critical thinking is the intellectually disciplined process that conceptualizes, applies, analyzes, synthesizes, and evaluates knowledge or information acquired through observation, experience, reflection, reasoning, or communication, as a guide to beliefs and action. According to Changwong et al. (2018), critical thinking is a multistep process. This process involves identifying problems, considering goals, gathering ideas for potential solutions, considering options, applying solutions, and assessing.

In real life, critical thinking skill is very important (Ikhsan et al., 2017; I Putu Yogi et al., 2021). According to Yaldiz and Bailey (2019), critical thinking skills train students to solve problems related to real life. Students need critical thinking skills to increase their mentality in facing real-life situations (Tuzlukova et al., 2017; Fathiara et al., 2019; Purnomo, 2022). These skills grow students' curiosity through deep reflection (Alfi et al., 2016; Angriani et al., 2016). Critical thinking rejects measuring students' intellectual growth (Luzyawati, 2017; Defiyanti & Sumarni, 2019). Students need critical thinking skills as a tool to solve real-life problems.

Munandar (2016) formulates that creative thinking has some indicators: flexibility, originality, fluency, and elaboration. In line with Utami, creative thinking has elements of flexibility, originality, fast thinking, independence, and thoroughness (Dewi, 2015; Gilhooly et al., 2015; Liu et al., 2015). Creative thinking combined with the new design will create new products (Sukmadinata & Syaodih, 2012). Creative thinking can combine prior inventions and discoveries to create new products.

Students' critical and innovative thinking skills are key skills in 21st-century international competition due to their levels. The complexity of the problems in all perspectives of modern life is really high. Critical and creative thinking is included in the realm of high-level cognition as a continuation of the principal competencies in the learning system (Piergiovanni, 2014; Liu et al., 2015). At this time, it is highly preferred if students can obtain those skills after the learning process with innovative learning examples that require the use. Based on studies by Halmaida et al. (2020), Dimmitt (2017), Susilawati et al. (2017), PjBL is more effective in increasing critical and creative thinking skills and learning outcomes. Group work helps increase creative thinking, problem-solving, and collaboration skills and look for problem solutions with fun learning by exploring students' skills.

The PBL model influences the increase in learning outcomes (Jusmaya & Efyanto, 2018; Binti, 2020). With critical and creative thinking skills, the PBL model can optimize students' thinking skills through the group work process so that students can improve, hone, and test their thinking skills simultaneously. Therefore, this research aims to compare the chemistry learning outcomes of students who are taught using PBL and PjBL models. In chemistry learning, teachers should choose the learning model that is appropriate to students' characteristics because every student requires different learning models. This study aims to compare the chemistry learning results of critical and creative students who are taught with PBL and PjBL models. From students' activities in each stage of PBL and PjBL models and data analysis procedure, it shows that there is no difference in learning outcomes of critical and creative students.

Based on the description above, a theoretical framework can be arranged as follows: (1) It is estimated that the learning model will provide higher chemistry learning outcomes than the syntax in the PBL model. It does not only solve problems but also produces solutions to the problem. Learning chemistry also requires creative thinking to solve problems. (2) In the learning process using the model, apart from being able to solve problems, students are required to be able to get real solutions in the learning process. Both PBL and PjBL can solve problems, but PBL only focuses on concepts while PjBL focuses on concrete form. On the other hand, critical thinking skills are addressed by problem-solving skills while students with creative thinking skills are not only able to solve problems but produce concrete results. Both students who have critical and creative thinking skills can solve problems but are critical only in concepts and creative students produce real work so it is suspected that there is interaction. (3) Students with critical thinking skills can solve problems and provide solutions in the form of concepts. Students with these criteria are thought to be more suitable for the PBL model in chemistry learning. (4) Students with creative thinking skills can solve problems and provide solutions with concrete results. Students with these criteria are thought to be more suitable for the learning model in chemistry learning. Based on this formulation, the following research hypotheses can be formulated: (1) There are differences in the chemistry learning outcomes of students with the PBL and PjBL models. PjBL learning outcomes are higher than PBL; (2) There is an interaction between thinking skills and learning models that give different learning outcomes; (3) For students with critical thinking skills, the PBL model is higher than PjBL; (4) For students with creative thinking skills, the learning model is higher than PjBL.

METHODS

The research setting was adjusted to the educational calendar at one of the South Tangerang Vocational High Schools in the 2021/2022 academic year. The treatment schedule was adjusted to the chemical pharmaceutical meeting schedule. This research was carried out in class XI of the pharmacy department which has 2 classes (XI Pharmacy 1 and XI Pharmacy 2). This study used a 2x2 factorial experimental design with ANCOVA statistical analysis. Experimental research explains the causal relationship between the dependent and independent variables (Loewen & Plonsky, 2017) with a 2x2 Factorial Design (Zalbidea, 2017). The research design is in Table 1.

Table 1. Research Design

		PjBL Model (A1)	**PBL Model (A2)**
Thinking Skills	Critical Thinking (B1)	A1B1	A2B1
	Creative Thinking (B2)	A1B2	A2B2

Table 1 shows that A1B1 is the group of students with critical thinking skills using the PjBL model, A2B1 is the group of students with critical thinking skills using the PBL model, A1B2 is the group of students with creative thinking skills using the PjBL model, and A2B2 is the group of students with creative thinking skills using the PBL model. The novelty of this method is to test the independent variables, namely two learning models (PJBL and PBL) on moderate variables (two groups of students with critical thinking skills and creative thinking skills). The dependent variable is chemistry learning results (outcomes).

In general, this study has several stages; 1) The study stage consists of three steps, namely making lesson plans, worksheets, and instrument evaluation for the test on critical and creative thinking skills and learning outcomes; 2) The implementation stage tests the initial skills of students to measure critical and creative thinking skills, so they can be assigned into the group following their thinking skills and for the second treatment, it is adjusted with the learning timetable; 3) In this stage, the final test is carried out to evaluate critical and creative thinking skills and learning results, followed by evaluating the data obtained. The treatment for the experimental class A1 is carried out using the PjBL model with several syntaxes. In the syntax "start with the essential question", students answer questions related to real life through deep investigation. In the syntax "design a plan for the project", students formulate the problems and decide the time to start the project. In the syntax "create the schedule", students create the project timetable. In the syntax "monitor the students and project progress", students are monitored and supervised for the projects they are carrying out. In the syntax "assess the outcome", the project products are assessed to fulfill the standard. In the syntax "evaluate the experience", students are asked to present their experience and improve the project performance. The treatment for the experimental class A2 was carried out by applying the PBL model syntaxes. In the orientation stage, students solve the problems given by investing deeply. In the 'organizing students to learn' stage, students learn to connect problems with the theory. In the "guiding individual and group observation" stage, students collect information. In the "developing and presenting the work" stage, students plan and prepare the work, analyze, evaluate, and present the work.

This research used a descriptive test as a data collection method. The instrument used was the critical thinking skill test consisting of four indicators proposed by Ennis (1996) and aspects of creative thinking, including flexibility, originality, fast thinking, and independence (Gilhooly et al., 2015; Liu et al., 2015). Before conducting the research, the questions had to be verified to see the level of validity, namely excellent, fair, and poor (Arifin, 2009). Validation consisted of content validity and construct validity (Arikunto, 2015). Validity test results showed that 18 out of 20 questions were valid. A reliability test was also carried out for the description test. A test is categorized as having high reliability if the results of the first and second tests are the same or have a strong relation (Surapranata, 2020). Reliability test results using Excel showed that $r_{count}=0.91>0.6=r_{table}$. Based on these data, the test instrument showed high reliability. The test instrument used in this study was in the form of essay questions given in the form of a pretest and posttest. This test instrument served to measure students' critical and creative thinking skills after and before learning was carried out using the PBL and PJBL models, content as seen in Table 2 and 3.

Table 2. Indicators of Critical Thinking

Number	Learning Indicators	Question Indicators	Cognitive domain	Indicators of critical thinking
1	Classify colloidal systems based on observations made.	Students present the tables of test results and classify what is included in colloids, suspensions, and solutions.	Analysis (C4)	Analyze argument
2	Classify colloidal systems based on observations made.	Students conduct colloid-making tests and categorize the techniques of making colloids.	Creation (C6)	Make definition
3	Conclude the properties of colloids and the manufacture of colloids based on observations of experiments	Students can infer how colloids are made by condensation and dispersion methods through precise experimental observations	Evaluation (C5)	Infer → induce and consider the results of induction
4	Analyze the properties of colloids	Students show pictures and news about spilled oil in Cilacap and analyze the properties of colloids and types of colloids in the news	Analysis (C4)	Analyze argument
5	Make a definition of colloidal properties based on logical arguments	Students show pictures and news about forest fires in Riau and define the nature of colloids and types of colloids	Evaluation (C5)	Infer → induce and consider the results of induction
6	Summarize the nature of colloids and the preparation of colloids based on experimental observations	Students present a description of the colloid coagulation experiment and find out the nature of colloids	Evaluation (C5)	Analyze arguments

Number	Learning Indicators	Question Indicators	Cognitive domain	Indicators of critical thinking
7	Design an experiment regarding the properties of colloids and the manufacture of colloids	Students present a description of marshmallows and design marshmallow tests.	Creation (C6)	Observe and consider the results of observations
8	Apply the properties of colloids and make colloids in daily life based on logical arguments	Students conduct slime-making tests in daily life and understand the types and properties of colloids.	Creation (C6)	Create definitions
9	Design an experiment regarding the properties of colloids and the manufacture of colloids	Students present an example of colloids and design a test.	Creation (C6)	Observe and consider the results of observations

Based on Table 2 and Table 3, the question instrument consists of nine critical thinking essay questions and nine creative thinking essay questions, showing five criteria using the Likert scale (Sugiyono, 2020).

Table 3. Indicators of Creative Thinking

Number	Learning Indicators	Question Indicators	Cognitive domain	Indicators of creative thinking
1	Analyze colloid properties	Students are given questions to identify examples of mixtures that are not colloids	Analysis (C4)	Flexibility
2	Apply colloid properties & make colloids in daily life based on logical arguments	Students are given questions to identify examples of mixtures that are not colloids	Creation (C6)	Flexibility
3	Summarize the nature of colloids and the preparation of colloids based on experimental observations	Students are given questions to identify examples of mixtures that are not a type of colloid.	Evaluation (C5)	Originality
4	Apply colloid properties & make colloids in everyday life based on logical arguments	Students are asked to give examples of the properties of colloids in daily life, including the Tyndall effect, Brownian motion, dialysis, coagulation, adsorption, and electrophoresis.	Creation (C6)	Flexibility
5	Make a definition of colloidal properties based on logical arguments	Students are asked to give examples of colloidal properties in daily life, including the Tyndall effect, Brownian motion, dialysis, coagulation, adsorption, and electrophoresis.	Evaluation (C5)	Originality
6	Summarize the nature of colloids and the preparation of colloids based on experimental observations	Students are asked to give some examples of the nature of colloids in marshmallows	Analysis (C4)	Originality
7	Analyze the colloid properties	Students are asked to give examples of the properties of colloids in daily life, including the Tyndall effect, Brownian motion, dialysis, coagulation, adsorption, and electrophoresis.	Analysis (C4)	Originality

Number	Learning Indicators	Question Indicators	Cognitive domain	Indicators of creative thinking
8	Design an experiment regarding the properties of colloids & the manufacture of colloids	Students are asked to make lyophile colloids and lyophobic colloids and identify them based on the difference in the nature of the two colloids	Creation (C6)	Originality
9	Make a definition of colloidal properties based on logical arguments	Students are asked to give examples of the properties of colloids in daily life, including the Tyndall effect, Brownian motion, dialysis, coagulation, adsorption, and electrophoresis	Evaluation (C5)	Flexibility

The following is the content outline of the question instrument for evaluating critical and creative thinking skills. This instrument had 7 questions in the difficult category and 11 questions in the medium category. This test was held before and after learning, six meetings with the PjBL model and four meetings with the PBL model. Data were then evaluated with inferential statistical tests including normality, homogeneity, and ANCOVA (Hidayatsyah, 2021). The number of tenth-grade students was 60; 30 were in the class with the PjBL model and 30 were in the PBL model. The sample selection was carried out using a purposive sampling technique where samples were taken considering certain characteristics (Campbell et al., 2020).

RESULTS AND DISCUSSION

First, the syntaxes of PjBL and PBL models of critical and creative students are presented in Table 2. The first activity is giving introduction tests for students to categorize those who have critical and creative thinking based on the test results. Then, students apply the PjBL model in the experimental class A1, and the others apply the PBL model in the experimental class A2.

Table 4. Syntaxes of PjBL and PBL Models in Critical and Creative Students

PjBL Steps	Syntax of Critical and Creative Student Activities				PBL Steps
Classification of Students	**Participants do a pretest to classify critical and creative students**				**Classification of Students**
Project Title	Slime, Ice cream, gelatin		Making ice cream		Problems
	PjBL Steps		PBL Steps		
Start with the essential question	Students provide answers to essential questions from the teacher, such as "Do you know colloids?"	Critical students provide arguments and conclusions Creative students express ideas to answer questions	Students orient themselves to challenges. Students articulate various concepts about making ice cream.	Critical students identify and look for causes of problems Creative students make lots of ideas and ways to solve problems	Orientation of students to problems
Design a plan for the project	Project preparation is to design the selected colloid project, free to do any project according to the colloid learning material theme	Critical students think of ideas and project-creation alternatives Creative students design and create new ideas	Group participants and communicate with each other, exchange perspectives, and contribute their own opinions	Critical students consider a source of information Creative students create ideas to find new solutions	Organize students to learn

Create a Schedule	Students make deadlines at each stage and determine the right way to do projects.	Critical students consider the use of appropriate procedures for doing projects	Investigating independently, students collect material to get problem-solving strategies by contributing ideas for the solution	Critical students consider ideas based on the consequences that will be received and think about alternatives in doing projects	Guide individual and group investigations
		Creative students add ideas to produce interesting products		Creative students design to create new ideas	
Monitor the students and the progress of the project	At this stage, the teacher records all student activities so that the project-making is more well-driven.	Critical students work on the project	Project presentation, where students plan and make reports to be presented to their classmates	Critical students make deductions and consider other groups' deductions	Develop and present their work
		Creative students work on the project		Creative students produce different thoughts in problem-solving.	
Asses the outcome	Students present their products	Critical students make deductions and consider the results of the deductions from the assessments of other	Study and assessment of solutions to these problems	Critical students define problems and select criteria to make solutions to problems	Analyze and evaluate the problem-solving process
		Creative students produce different thoughts in problem-solving		Creative students look for deeper meanings for answers or problems so that they enrich an idea or product	
Evaluate the experiences	Students reflect on the project-making process	Critical students criticize the resulting project.			
		Creative students add project details			

Second, data description, test analysis statement, review, and hypothesis testing used ANCOVA statistical test. The use of ANACOVA was due to the presence of accompanying variables that are difficult to control but can be measured with the dependent variable (Silaen et al, 2021). PjBL and PBL were applied to chemistry material about colloids. The test was given using a learning outcome evaluation instrument that has been validated. The results of the description data analysis are in Table 5.

Table 5 presents the learning outcomes of students who have taught using the PBL and PjBL models separately, including the highest, lowest, average, and median scores, and standard deviation.

Table 5. Results of Descriptive Data Analysis

Skills Thinking (B)		Learning Model (A)			
		PjBL Model		PBL Models (A_2)	
		Initial Skills (X)	Learning Outcomes (Y)	Initial Skills (X)	Learning Outcomes (Y)
B1 (Critical)	Number of Samples	30	30	30	30
	Average	69	79	64	78
	Median	69	79	63	77
	Maximum score	87	98	84	96
	Minimum score	51	62	47	60
	Standard Deviation	8.1	11.8	9	11
B2 (Creative)	Number of Samples	30	30	30	30
	Average	73	86	70	84
	Median	73	87	71	84
	Maximum score	82	98	80	96
	Minimum score	60	73	58	71
	Standard Deviation	5.9	5.7	5.3	5.6
Number of Samples		30	30	30	30
Average		71	83	68	81
Median		70	82	67	80
Maximum score		83	94	81	92
Minimum score		63	72	60	70
Standard Deviation		5.6	6.2	5.6	6.1

The homogeneity test of normality and variance is a prerequisite for assessing this study (slope homogeneity). The results of the normality test and the homogeneity test of the Kolmogorov-Smirnov SPSS are shown in Table 6, Table 7, and Table 8.

Table 6. Normality Test Results of the PjBL Model

	Pretest	Posttest	Pretest of critical thinking	Posttest of critical thinking	Pretest of creative thinking	Posttest of creative thinking
P-value	0.795	0.745	0.953	0.459	0.592	0.195

Based on Tables 6 and 7, the normality test results of the PBL and PjBL classes obtain more p-value of 0,05. Thus, it can be interpreted that data are normally distributed and can be used for the next stage. Homogeneity is a presumption condition that must be fulfilled when conducting an analysis of variance and covariance.

Table 7. Normality Test Results of the PBL Model

	Pretest	Posttest	Pretest of critical thinking	Posttest of critical thinking	Pretest of creative thinking	Posttest of creative thinking
P-value	0.601	0.815	0.615	0.558	0.114	0.548

From Table 8, it is obtained that the statistical p-value is higher than the significance value of 0.05 so it can be concluded that the variance of class scores of students with creative and critical thinking skills using the PjBL model is the same as the variance of students using the PBL model. Based on the normality test, it is normally distributed.

Table 8. Homogeneity Test Results of the PjBL and PBL Models

	Posttest	Posttest of critical thinking	Posttest of creative thinking
P-value	0.908	0.878	0.942

These values are obtained based on the tests conducted at SMK Kesehatan in South Tangerang. This study seeks to determine the effect of learning models and cognitive skills on student learning outcomes to show the following: 1. Differences in chemistry learning outcomes between students taught using Project-based learning (A_1) and students taught using Problem-based Learning (A_2). The results of the covariate analysis in groups A1 and A2 are summarized in Table 9.

Table 9. Hypothesis 1

Source	Amount of square	df	Mean square	F	Sig
Corrector models	90233	2	45,116	1,160	,321
Intercept	2120848	1	2120848	54,550	,000
Size	21,966	1	21,966	,565	,455
Group * Measure	44,869	1	44,869	1,154	,287
	2216.100	57	38,879		
Error					
Total	404108,000	60			
Total corrected	2306333	59			

2. The interaction effect between the learning model and thinking skills on chemistry learning outcomes

Interaction test results between learning models and students' characteristics (critical and creative) are shown in Figure 1.

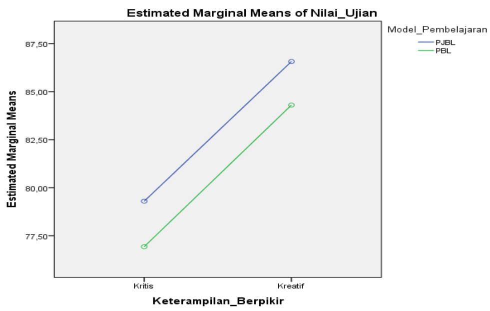

Figure 1. Interaction

3. Differences in chemistry learning outcomes between students taught using the PjBL model and students taught using the PBL model in critical thinking skills

The results of covariate analysis among groups A_1B_1 and A_2 B_1 are summarized in Table 10.

Table 10. Hypothesis 3

Source	Amount of square	df	Mean Square	F	Sig
Corrector models	124282	2	62,141	,504	,607
Intercept	6730403	1	6730403	54,587	,000
Size	40,265	1	40,265	,327	,570
Group * Measure	107,491	1	107,491	,872	,354
Error	7027901	57	123,297		
Total	373285000	60			
Total corrected	7152.183	59			

4. Differences in chemistry learning outcomes between students taught using the PjBL model and students taught using the PBL model in creative thinking skills. The results of covariate analysis among groups A_1B_2 and A_2B_2 are in Table 11.

Table 11. Hypothesis 4

Source	Amount of square	Df	Mean Square	F	Sig
Corrector models	137091 -	2	68,545	2.147	,126
Intercept	1883,978	1	1883,978	59015	,000
Size	60,024	1	60,024	1,880	, 176
Group * Measure	49,003	1	49,003	1.535	,220
Error	1819642	57	31,924		
Total	439888,000	60			
Total corrected	1956,733	59			

Based on the findings syntax in Table 2, there is a similarity between the PjBL "design a project" and the PBL "guide individual and group investigation". Critical students consider the idea based on consequences and think of alternatives in a project. In comparison, creative students design and create new ideas or products. The PjBL stage assesses a product, while PBL develops and presents results. Critical students make deductions and consider the results from the assessment of other groups, meanwhile, creative students give opinions, bring up flexible and original thinking, and produce different thoughts in solving problems. The difference is, in this case, that PjBL produces a product whereas PBL delivers a solution to a problem. PBL solves problems where the ice cream is a liquid emulsion colloid and liquid foam because in making ice cream, gelatin is used (colloid crystals ice by mixing dragon fruit juice as natural coloring and flavoring) CMC in making homemade ice cream. In PjBL, students make various products, such as slime, ice cream, and jelly, using natural ingredients, dragon fruit.

The challenges faced by teachers with PjBL include time allocation outside class hours, limited facilities or infrastructure, and unfamiliarity with this learning model. Teachers are still unable to choose projects that are appropriate to the learning model. The inhibiting factors include the high cost, lack of PjBL training, the absence of project-based worksheets, the lack of student independence, and the long evaluation process. Most of the obstacles faced by teachers in implementing PBL are caused by the initial skills, thinking skills, level of self-confidence, and several other heterogeneous student variables. In addition to the lack of learning tools and the disparity in the number of students and teachers in the class, teachers also face additional challenges in implementing the PBL model and choosing problems that are appropriate to the learning topic and the different backgrounds of the students. This reason makes the teachers unable to observe the students as a whole. Another difficulty in implementing the PBL model is that there are quiet students, so they are not active in discussions. Learning happens through a reflective activity process to build cognitive that can develop ideas, obtain information critically, and be more ready to solve problems based on learning (Black & Allen, 2018; Pertel et al., 2020).

The hypothesis testing with ANCOVA shows several results. First, chemistry learning outcomes in colloid materials of students taught using PjBL have an average of 82.9, while students taught using PBL have an average of 80.7. This number shows that the chemistry learning outcomes in colloid materials of students taught PjBL are almost the same, or there is no significant difference with students taught with the PBL after controlling initial skills. Figure 2 illustrates the results. However, based on ANCOVA test results, the p-value exceeds the significant level 0.05, namely $0.287 > 0.05$; it fails to reject H_o, which means that there is no significant difference between the learning outcomes.

Second, assessing the effect of the interaction of learning models and thinking skills on chemistry learning outcomes. Based on Figure 3, students with critical thinking skills have lower test scores than students who have creative thinking skills. In addition, students taught with PjBL have higher test scores than those taught with PBL. The groove does not cut the line between one another or show alignment so that there is no interaction between thinking skills and learning models influencing students' test scores. Based on descriptive analysis of chemistry learning outcomes in colloid materials, students with critical thinking skills taught using PjBL have an average of 79.3, meanwhile students with critical thinking skills taught with PBL have an average of 76.9. The results show that the chemistry learning outcomes in colloid materials of students with critical thinking skills taught using PjBL are almost the same, or there is no significant difference with those taught using PBL after controlling the initial skills. Figure 4 illustrates the results. Based on the ANCOVA test obtained, the p-value exceeds the significant level 0.05, namely $0.354 > 0.05$, so it fails to reject H_o which means that there is no difference in chemistry learning outcomes between students with critical thinking skills taught using PjBL and PBL.

Third, based on descriptive analysis of chemistry learning outcomes in colloid materials, students with creative thinking skills taught using PjBL have an average of 86.5, while students with creative thinking skills taught using PBL have an average of 84.3. The results show that the chemistry learning outcomes in colloid materials of students with creative thinking skills taught using PjBL are almost the same, or there is no significant difference with those taught using PBL after controlling the initial skills. It can be seen in Figure 5. Based on the ANCOVA test, the p-value exceeds the significance level of 0.05, namely $0.220 > 0.05$. It fails to reject H_o, which means that there is no difference in chemistry learning outcomes between students with creative thinking skills taught using PjBL and PBL.

From the results of the ANCOVA test on hypotheses 2 and 3, there is no significant effect on the interaction between learning models and thinking skills on students' learning outcomes after initial control of students' skills in each class. This is also due to the Covid-19 situation which made the government stop school activity (Asmuni, 2020; Maulana & Hamidi, 2020). Due to the pandemic, face-to-face learning was shifted to online learning (Fadlilah, 2020; Wahyono et al., 2020), and then it was limited. Based on the analysis of questions on PjBL and PBL, the critical thinking indicator of analyzing arguments obtains the highest average score of 92 in the PJBL and the highest average of 83 in the PBL, where students were asked to conclude colloid properties and make colloids based on research observations. Then, the critical thinking question indicator of concluding → inducing and considering the results of induction with an average score of 90 in the PjBL and the highest average score of 83 in the PBL, where students are asked to make a definition of colloid properties based on logical arguments and thinking indicators. The critical thinking indicator of making definitions and indicators, observing, and considering the results of observations obtains the lowest average score in the PjBL and PBL models, where students are asked to classify colloidal systems based on observations.

Based on the creative thinking indicator analysis, the indicator of flexibility obtains the highest score of 92 for the PjBL and 88 for the PBL. The increased flexibility occurs because students can apply colloid properties and make colloids based on logical arguments in daily life. The PjBL class obtains an average score of 90 for the indicator of originality, while the PBL obtains 85. Because the experimental designs made by students during the learning process can increase their confidence in the results of their thinking, students usually do not look for similar answers from other groups or books to increase their confidence. The indicator of fluency obtains a score of 82 in PjBL and PBL classes. Students with fluent thinking skills will provide comprehensive responses. The more answers given, the more fluent students think. However, some students are less thorough and still make mistakes when answering questions. This indicator obtains the lowest score, indicating that students cannot think divergently to produce several ideas.

When taught using PBL and PjBL, it is expected to accommodate fluency where students are very enthusiastic about finding problems from problem articles, pictures, and videos and trying to find solutions to these problems from other supporting books and discussing them with their peers. However, sometimes students do not focus on the problem they are looking for. In addition, in almost every application of the PBL and PjBL, students are directed to developing more fluent thinking skills, the obstacles teachers face to determine the skills of students without a high level of critical thinking. Some students have not been able to articulate their thoughts, so they still struggle to articulate the challenges they face during the learning process. Students' low learning awareness is seen from the lack of enthusiasm when the learning process begins. Students are still adapting from online to offline learning, whereas they only study online and face-to-face learning transitions during junior high school. It only allows them to attend school for 2 hours, making it less effective. Students' lack of creativity and involvement in learning is a challenge in this problem. As a result, students are not ready to understand, assimilate, and react to the material and problems. The dynamic nature of asking and answering questions, expressing ideas, and solving problems creatively can help students develop their critical thinking skills. The absence of differences in the implementation of the learning process between PjBL and PBL is a factor that must be emphasized to stimulate learning outcomes with critical and creative thinking skills. However, based on the data, the PjBL class is superior in learning outcomes in critical and creative thinking compared to the PBL class.

CONCLUSION

Based on the results and discussion that have been described, it can be concluded that there is no difference in testing PjBL and PBL models in critical and creative students in colloid materials, and there is no interaction between thinking skills and learning models in chemistry learning outcomes, there is no difference in learning outcomes of students with critical thinking skills both in PjBL and PBL models. In the PBL model syntax, namely guiding individual and group investigations, critical students take action and consider ideas based on the consequences to be received and think of alternatives in making a project. Meanwhile, creative students design and create new ideas or products. At the "assess the product" stage in the PjBL model and at the "develop and present the result" stage in the PBL model, critical students make deductions and consider the results of the deductions from the assessments of other groups, while creative students give opinions by thinking flexibly and originally and produce different thoughts in solving problems.

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