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THE EFFECTIVNESS OF PROBLEM BASED LEARNING AND PROJECT BASED LEARNING BASED ON ETNOMATEMATHICS BATIK PURWOREJO IN TERMS CRITICAL AND CREATIVE THINKING ABILITY

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ABSTRACT
This study aims to describe the effectiveness of the Problem Based Learning (PBL) and Project Based Learning (PjBL) models in the context of Batik Purworejo, particularly regarding the critical and creative thinking abilities of junior high school students. This research is a quasi-experimental study involving the population of ninth-grade students at SMP Negeri 2 Purworejo for the 2023/2024 academic year. Samples were randomly selected from two classes, IX A using PjBL and IX B using PBL. The research instruments consisted of validated tests to measure students' critical and creative thinking abilities. Data analysis was performed using the One Sample t-test for PBL and N-Gain for PjBL, as well as the Wilcoxon Signed Rank test to compare the two models. The results indicated that the PBL model is effective in enhancing critical thinking, while PjBL also proves effective in the same aspect. However, the PBL model was not effective in improving creative thinking, whereas PjBL was found to be effective. Additionally, PjBL was more effective than PBL in enhancing critical thinking, although both models did not show significant differences in improving creative thinking abilities.

Keywords: Project Based Learning, Problem Based Learning, Batik Purworejo, critical thinking, creative thinking

INTRODUCTION

The covid-19 pandemic that hit Indonesia has had a major impact on education in Indonesia. The impact of the pandemic has caused the change in learning that was previously carried out face-to-face to distance learning. A study conducted by the Education Standards, Curriculum, and Assessment Agency in 2021 found impacts on the learning process during the pandemic, including learning loss, which is when students lose competencies that should be learned before the next level material. Learning in the classroom is not complete and students do not master learning at each level, so they experience other negative impacts.

Another impact of the disruption of the learning process during the pandemic is the occurrence of a learning gap during distance learning between one region and another, which results in a widening gap in student learning outcomes. To reduce the impacts of learning during the pandemic and improve the quality of learning, the government provides an alternative to the independent learning curriculum as a solution for this goal. The Independent Curriculum places students as the center of learning, which means teaching concepts according to their abilities at that time and exploring students' abilities by multiplying projects that make students more independent. Teachers can choose the format, essential materials, and learning methods that are applied to students. However, not all schools have used the independent curriculum, this curriculum has only been tested in several schools and has only been officially launched in 2022 by the Ministry of Education and Culture (Ministry of Education and Culture, 2022).

In post-pandemic conditions, the implementation of proper learning is needed. Meaningful learning is learning that is in accordance with current conditions. Meaningful learning can be used in learning the independent curriculum and the revised 2013 curriculum. Meaningful learning according to Ausubel (2000:1) is the process of relating new material to pre-existing concepts. Meaningful learning is closely related to constructivist learning. Adherents of constructivism argue that students will construct knowledge or gain meaning as a result of thinking and interacting in the learning process.

Constructivism learning theory is a theory about the creation of meaning in the learning process. Piaget, who is a believer in constructivism, revealed that a person can create his own knowledge through the interaction between ideas and experiences. Piaget's view of constructivism is the basis for the idea that students are the center of learning. Piaget explained that the results of previous experience and knowledge had to be modified and assimilated. Piaget's opinion is strengthened by Vygotsky stating that the best learning process is through interaction with the surroundings, through an interaction students can improve their experience to build their knowledge (in Kimmons & Caskurlu, 2020).

One of the learning approaches that uses constructivism is the scientific approach. According to Permendikbud Number 103 of 2014, a scientific approach is applied in a learning activity that creates a learning experience in the form of observing, questioning, gathering information (trying), reasoning (associating), and communicating. To gain these five experiences, in Permendikbud No. 22 of 2024, learning should provide opportunities for teachers to apply real materials or contexts, encourage interaction and active participation of students, and use resources in the surrounding environment. The learning models in question include discovery/inquiry learning, problem-based learning, and project-based learning. The three learnings contain a series of activities that support students to gain experience in creating their own knowledge. Activities in the learning process encourage students to actively interact with their learning environment, in addition to the activities in learning are arranged in order to train students in solving given problems. Thus indirectly students are trained to have social skills and thinking skills that will be useful in their lives in the future.

Currently, 21st century capabilities are still a topic that is often discussed. The capabilities of the 21st century are considered to be able to answer future challenges. Education in schools is required to find ways that enable learners to succeed at work and in life through the mastery of creative thinking skills, flexible problem-solving, collaboration and innovation. The 21st century abilities that every individual must possess include the ability to think critically, think creatively, collaborate and communicate. 21st century skills are needed by students to be able to face complex life challenges in the future (Mobo et al, 2021: 115). The skills that have been mentioned can be obtained by students by applying learning methods that are in accordance with a series of activities that support the development of these abilities.

In addition, critical and creative thinking skills are one of the important components of high-level thinking skills that need to be developed in schools. Higher Order Thinking Skill (HOTS) is a high-level thinking skill for a person to think critically, creatively, and analytically about information and data in solving problems (Jannah et al., 2022). Critical thinking is necessary for students so that they are able to become free, creative, and responsible thinkers and can provide criticism of various circumstances in society, especially government policies.

Critical thinking skills are one of the important 21st century skills for students to have. The ability to think critically is the capital to make decisions more wisely throughout his life. A person who has the ability to think critically will use his beliefs, opinions, and thoughts to solve complex problems (Sani, 2019: 24). The importance of students' critical thinking skills is not supported by the reality in the field. Palinussa (2013) found that the critical thinking skills of students who were given per practice of the culture-based RME learning model were only 60.48 out of a maximum score of 100. Rohaeti and Koswara (2018) in a study found that students' mathematical critical thinking skills are at a low level. Nuryanti, et al (2018) also found that the critical thinking skills of junior high school students are still low.

The low critical thinking ability of students is strengthened by the results of the Programme for International Student Assessment (PISA) where one of the components tested is the process component, namely the ability to formulate mathematical problems, use the correct concepts and procedures, and evaluate the results obtained so that they can measure students' critical thinking skills. The results of PISA 2018 show that Indonesia is still in 73rd position out of 80 countries with a score of 379 in mathematical ability (Ministry of Education and Culture, 2022). This was exacerbated by the PISA results, especially in the field of mathematics, which fell by almost 15 points from 2018. The score obtained by Indonesia is still far from the target of the 2024 National Medium-Term Development Plan (RPJMN) (Kompas, 2023). The things mentioned above show that the critical thinking ability of students in Indonesia is still low.

Another 21st century ability is the ability to think creatively. Think creatively in creating various new innovations that will make students able to survive and not be replaced by machines in their field of work. In addition, creative thinking in mathematics is necessary to solve complex mathematical problems. This opinion is in line with the thinking of Siswono et al (2022: 75) who stated that in solving mathematical problems, students are not only equipped with mathematical understanding and skills but must also be equipped with creative thinking skills. The importance of creative thinking skills is still an important task for the government to improve it. The findings of Rahmawati (2016) show that students' mathematical creative thinking ability shows a low average of 50.27. This is strengthened by research by Huda et al (2019) which showed that out of 25 students, 21 of them had medium and low creative thinking skills. Fardah (2020) found that students' ability to solve math problems in creative thinking was in the high category as much as 20% of the number of students, medium as much as 33.33%, and low as much as 46.67%. Apart from the results of the research that has been mentioned, the decline in math scores in PISA 2022 can also indicate students' low creative thinking skills. This can be said because PISA is one of the measuring tools to measure students' high-level thinking ability, one of which is creative thinking ability. The results of the study show that many students in Indonesia still have low creative thinking skills.

The low ability of students' critical and creative thinking skills requires serious government efforts to improve it. The development of critical thinking and creative thinking skills requires a good and appropriate learning method. Critical thinking skills require continuous learning and practice in order to develop in a better direction (Redhana, 2012). Critical thinking and creative thinking skills are one of the components of contextual learning (Samo, 2017). Contextual learning refers to learning mathematics as part of a student's life. Contextual learning is in accordance with the Problem Based Learning and Project Based Learning learning models recommended by the Ministry of Education and Culture. In Problem Based Learning, there are problem-solving activities that can contain contextual problems in daily life. Similarly, the Project Based Learning learning model where learning activities create projects that produce a real product.

Indonesia is a country rich in culture. Cultural themes can also be used as contextual problems in both learning models that will be applied in classroom mathematics learning. Learning mathematics using regional culture is known as ethnomathematics. The Ethnomathematics perspective in learning mathematics in schools is a hope to improve students' ability to understand the material and improve their thinking skills in solving mathematical problems. The content of mathematics and culture in the environment around students has a connection and attachment to each other (Civil, 1995). Ethnomathematics exists to bridge students to learn to understand mathematics through culture.

One of Indonesia's cultural heritage is batik. Batik has different characteristics in each region. Purworejo Regency also has its own typical batik from other batik. Purworejo batik uses motifs that have become icons of the district. In this study, the researcher used Purworejo Batik which will later be presented into contextual problems. The process of making Purworejo batik motifs can be a contextual problem in Problem Based Learning and Project Based Learning. Purworejo batik uses a lot of motifs by applying geometric transformations. Research on mathematical concepts in Batik. One of them is Fadila (2017) examines Lampung Batik which contains the concept of geometric transformation. Ariono & Ferima (2020) also studied the elements of Geometric Transformation in the motifs of Batik Surya Majapahit and Sisik Gringsing in Mojokerto Regency. The use of batik context is expected to be able to improve students' critical and creative thinking skills in geometry transformation materials. Many studies on the elements of mathematics in Batik motifs have been researched, but there are still not many who apply learning in the context of batik as learning in the classroom.

Batik contains geometric patterns that can be used as a medium to learn about geometry and geometry transformation so that it can help students have difficulties in solving problems related to geometry transformation. Many students still encounter difficulties in solving problems related to geometry transformation (Sholihah & Afriansyah, 2017). These findings are strengthened by research conducted by Giovani et al (2023) that students make many mistakes in solving problems regarding geometric transformations. The study showed that many students had difficulty solving problems related to geometric transformation.

Low critical and creative thinking skills are problems that must be faced by teachers. Teachers must be able to guide students to have these abilities. One way to improve critical thinking skills and creative thinking skills is to use a learning model that trains children to develop thinking skills. In reality, the learning model implemented in schools for the most part still maintains the lecture learning model (Fauzi, 2021: 3). The lecture learning model makes students passively listening and taking notes. To improve critical and creative thinking skills, serious efforts are needed. This is reinforced by Prihono & Khasanah (2020) who state that the problem learning model involves activity and creativity in the problem-solving process. The problem-based learning model is known as Problem Based Learning. In addition to the Problem Based Learning model, the project-based learning model or known as Project Based Learning is able to help students develop their thinking skills in problem-solving activities by creating a project and training students' creative thinking skills (Rahman, 2022: 10).

Various studies have been conducted to improve critical thinking and creative thinking skills with the learning models that have been mentioned. There are still studies that are still not as expected, one of which is a study conducted by Happy & Wijayanti (2019) showing that Problem Based Learning has not been effective in improving students' critical thinking skills even though it is better than conventional learning models. The ineffectiveness turned out to be due to the implementation of learning, students still found difficulties in understanding the problems and the lack of meetings held. In addition, the problems presented emphasize more on the aspects of focus, reason, and, inference of other aspects such as situation, clarivy, and overview are still weak. The study shows that the application of Problem Based Learning in the classroom has not been maximized to improve critical thinking skills so it needs to be further developed. In addition, the research that has been carried out is still limited to certain materials.

Amalia, et al (2019) conducted a study using the Problem Based Learning (PBL) learning model with the theme to improve the creative thinking skills of junior high school students with effective results. The N-gain data in PBL-Themed of 0.52 is included in the medium category, the average increase in mathematical creative thinking ability in PBL-Themed is better than the average increase in mathematical creative thinking ability in PBL. Simanjuntak (2020) compared the use of the Problem Based Learning learning model with the conventional learning model, the results showed that the Problem Based Learning learning model was more effective than the Conventional learning model to increase creative thinking in junior high school students in Number Pattern material. The use of Problem Based Learning to improve creative thinking is still in the medium category and has not been maximized. Research conducted to see the effectiveness in improving critical thinking skills is also still limited to certain materials. So it can be said that the use of the Problem Based Learning learning model in improving critical and creative thinking skills has not been maximized and is still limited to certain materials, so further studies on other materials are needed.

Project Based Learning as a cognate learning model with the Problem Based Learning learning model is also considered to be able to improve students' critical and creative thinking skills. Project-based learning makes students practice to pour out ideas to solve the problems at hand by creating a single project. Project-making activities can also attract students' interest in learning mathematics and the learning becomes more meaningful. The projects that students use should be chosen according to their environment so that students feel that mathematics is in their environment. Several studies have been conducted to determine the effectiveness of the Project Based Learning learning model in the learning process to improve students' critical and creative thinking skills, especially at the junior high school level, among which are Prihatiningtyas et al (2020), Lestari & Ilhami (2022), Yanti & Novaliyosi (2023), and Rahmawati (2023) which shows that the Project Based Learning learning model is effective in improving critical thinking and creative thinking skills. The research that has been mentioned is still limited to certain materials only, so further studies of other materials are needed because not all materials can be set for project-based learning.

Given the importance of critical thinking skills and students' creative thinking skills, innovation is needed to improve these abilities. The innovation that will be carried out by the researcher is to implement the Problem Based Learning and Project Based Learning learning models with the context of Purworejo batik. In this study, the effectiveness of both will be examined from the ability to think critically and creatively in solving geometric transformation problems.

The purpose of this study is to describe the effectiveness of the Problem Based Learning (PBL) and Project Based Learning (PjBL) learning models in the context of Purworejo Batik, especially related to the critical and creative thinking skills of junior high school students. This study aims to evaluate the effectiveness of PBL and PjBL in improving students' critical thinking skills, as well as compare the two models in terms of their impact on creative thinking skills. The results of the research are expected to provide theoretical benefits by enriching empirical studies on PBL and PjBL in the context of Purworejo Batik, thereby contributing to the development of mathematics education. Practically, this research benefits mathematics teachers by increasing their creativity in developing interesting learning models and expanding understanding of the application of PBL and PjBL in mathematics teaching. For students, this research is expected to encourage active and creative participation during learning activities, provide meaningful learning experiences in acquiring mathematical knowledge, and develop critical and creative thinking skills that are important for solving problems in real life. In addition, this research aims to increase students' appreciation of the cultural heritage of Purworejo Batik, which will enrich their understanding of local traditions.

RESEARCH METHOD

This study uses a quasi-experiment method, which is a type of quantitative research. Quantitative research aims to test theories by examining the relationships between variables. In this study, two groups of students from one school who were at the same grade level were used to compare the effectiveness of the learning model. The experimental design applied was non-equivalent groups pretest-posttest control group design. The research steps have been designed beforehand, starting with compiling research instruments such as syllabus, learning implementation plans, and question grids to measure students' critical and creative thinking skills. After going through a validation process by expert lecturers, the instrument was tested to ensure its reliability before being used in the study by giving a pretest and posttest to both experimental classes. The data obtained from the pretest and posttest will be analyzed using descriptive and inferential analysis. In the descriptive analysis, data is processed to determine the average, standard deviation, and category of effectiveness of the learning model based on the minimum completeness criteria (KKM) set. Meanwhile, inferential analysis was used to test the hypothesis about the effectiveness of the Problem Based Learning and Project Based Learning learning models on students' critical and creative thinking skills. Before performing the follow-up test, the assumption of normality and homogeneity is tested to determine the type of statistical test to be used. The normality test was performed with the Kolmogorov-Smirnov, while the homogeneity test used the Levene's test. For effectiveness analysis, hypotheses were tested using one sample t-test for normally distributed data, and N-gain for abnormal data. If there are significant differences, further analysis will be performed to determine which variables contribute to the difference.

RESULT AND DISCUSSION

Inferential Data Analysis

Inferential analysis aims to analyze sample data and the results will be concluded to find out the truth of the hypothesis determined. Inferential statistics provide an objective way to collect, process, and analyze quantitative data and then draw conclusions based on population characteristics based on the results of a randomly selected sample of a population (Sutopo & Slamet, 2007). The data analysis in this study is divided into data analysis before and after the study.

A. Assumption Test

The purpose of the assumption test is to find out the test statistics used in making decisions. The assumption test carried out before conducting a hypothesis test in making a decision is a normality test and a homogeneity test both univariate and multivariate. The normality test aims to find out whether the data is distributed normally or not. The homogeneity test aims to find out that the data comes from a group that has the same variance (homogeneous).

1) Multivariate Normality Test

The multivariate normality test was used to see the normality of data distribution, critical thinking and creative thinking skills. In each class, the normality test was multivariated by looking at the distance of the mahalanobis. Normality tests are performed to determine what statistics are used to test

hypotheses, if the data is normally distributed then parametric statistics will be used for subsequent testing. If the data is abnormally distributed, non-parametric statistics will be used for the next test. The hypothesis for the multivariate test is as follows.
H0: sample data from a normally distributed population
H1: sample data are from abnormally distributed populations.

The data is normally distributed when the data has an anobic distance of less than or equal to $\chi 2$ (0.5). which is 1.39 a maximum of 50% of the overall data. The level of significance used is 0.05. If the value is from $d2 \leq \chi 2$ (0.5). then H0 is accepted which means that the sample data is normally distributed.

The data used were pretest and posttest data on the critical and creative thinking skills of each experimental class. Pretest data is calculated at a distance to analyze whether the data is normally distributed or not. The values of the results of the calculation of the distance of the anobis and the value of $\chi 2$ are presented in the following table 19.

Table 1. Distance of Mahalanobis Classroom Pretest Data with Problem Based Learning Learning Context Purworejo

No	Jarak Mahalanobis	No	Jarak Mahalanobis
1	0.05865	17	1.07379
2	0.05865	18	1.32780
3	0.13832	19	1.42213
4	0.20031	20	1.66647
5	0.21236	21	1.86401
6	0.22316	22	1.90356
7	0.35747	23	2.45580
8	0.43810	24	3.83158
9	0.44533	25	4.04432
10	0.74859	26	4.21276
11	0.81554	27	4.39127
12	0.84336	28	4.56987
13	0.92373	29	4.66452
14	0.92373	30	4.72374
15	1.07379	31	4.98299
16	1.07379	32	6.33054

Table 1 shows that 56% of the costanobis value is less than 1.39 which results in Ho being rejected. The null hypothesis was rejected showing that the data from the pretest data value from the sample treated with Problem Based Learning treatment in the context of Batik Purworejo was not distributed normally.

Table 2. Distance Mahalanobis Pretest data from class with Project Based Learning learning model in the context of Purworejo Batik

No	Jarak Mahalanobis	No	Jarak Mahalanobis
1	0.07548	17	1.04149
2	0.19035	18	1.04149
3	0.36495	19	1.28255
4	0.37652	20	1.28255
5	0.37652	21	1.52214
6	0.51443	22	1.72845
7	0.51443	23	2.89211
8	0.51783	24	2.89211

9	0.55762	25	3.35734
10	0.63097	26	3.45767
11	0.64915	27	3.50455
12	0.73378	28	3.70293
13	0.73378	29	4.23382
14	1.01670	30	5.96734
15	1.01670	31	7.34186
16	1.01670	32	7.46570

Table 2 shows that 62.5% of the costanobis value is less than 1.39 which results in Ho being rejected. The null hypothesis was rejected showing that the data from the pretest value of the data from the sample treated with Project Based Learning treatment in the context of Batik Purworejo was not normally distributed. Postest data is calculated the distance of the most important to analyze whether the data is normally distributed or not. The values of the results of the calculation of the distance of the mahalanobis and the value of $\chi 2$ are presented in the following tables 21 and 22.

Table 3. Distance expensiveanobis postest class results Problem Based Learning Context Batik Purworejo

No	Jarak Mahalanobis	No	Jarak Mahalanobis
1	0.14139	17	0.93704
2	0.14245	18	1.12939
3	0.14245	19	1.17200
4	0.18053	20	1.60093
5	0.18587	21	1.89284
6	0.18587	22	2.11439
7	0.27471	23	2.28022
8	0.28263	24	2.50520
9	0.28433	25	2.56338
10	0.41639	26	2.89746
11	0.42394	27	2.99835
12	0.43784	28	3.93290
13	0.44971	29	4.91139
14	0.48831	30	5.68068
15	0.51602	31	6.93186
16	0.58285	32	13.31665

Table 3 shows that 56% of the costanobis value is less than 1.39 which resulted in Ho being rejected. The null hypothesis is rejected showing that the data from the data postet value of the sample treated with Problem Based Learning in the context of Batik Purworejo has no normal multivariate distribution.

Furthermore, after testing the normality of data from the Problem Based Learning class in the Purworejo batik context, the same assumption test will also be carried out for classes that apply the Project Based Learning learning model in the Purworejo Batik context. The data tested for normality was the postest data on critical thinking skills and creative thinking skills from the Problem Based Learning class in the Purworejo batik context.

Table 4. Distance Mahalanobis postest results of the Project Based Learning class Batik Purworejo

No	Jarak Mahalanobis	No	Jarak Mahalanobis
1	0.02440	17	0.69279
2	0.06460	18	0.74379

3	0.06460	19	0.74692
4	0.09411	20	0.96851
5	0.12834	21	1.11511
6	0.12834	22	1.26436
7	0.12834	23	1.37392
8	0.27590	24	1.37392
9	0.27590	25	1.57731
10	0.35578	26	2.20385
11	0.45038	27	2.64003
12	0.45038	28	2.64003
13	0.45940	29	2.86862
14	0.50726	30	2.86862
15	0.62139	31	16.64580
16	0.63210	32	17.61510

Table 4 shows that 75% of the costanobis value is less than 1.39 which shows that Ho is rejected, which is the conclusion that the data from the sample treated with Project Based Learning Batik Context is not normally distributed in a multivariate manner.

2) Univariate Normality Test

In addition to being tested for normality in a multivariate manner, the normality of each variable that has been measured is also tested. The univariate normality test is carried out to find out whether the data of each sample class comes from a class that is normally distributed or not so that statistical tests can be determined in making decisions.

The univariate normality test was carried out with the Kolgomorov Smirnov test with the help of the SPSS 25 for windows trial version. The hypothesis used is as follows.

i. Critical thinking skills

H0: critical thinking ability data from a normally distributed population.

H1: Critical thinking ability data comes from abnormally distributed populations.

ii. Creative thinking skills

H0: creative thinking ability data comes from a normally distributed population.

H1: data on creative thinking ability come from abnormally distributed populations.

The results of the normality test of each variable are presented in the table below.

Table 5. Univariate normality test results

Class	**Variabel**	**Statistics**	***p-value***
Before being given treatment			
Problem Based Learning Context of Purworejo Batik	Critical Thinking	0.123	0.200
	Creative Thinking	0.118	0.200
Project Based Learning Context of Batik Purworejo	Critical Thinking	0.145	0.085
	Creative Thinking	0.292	0.000
After being given treatment			
Problem Based Learning Context of Purworejo Batik	Critical Thinking	0.145	0.087
	Creative Thinking	0.271	0.000
Project Based Learning Context of Batik Purworejo	Critical Thinking	0.213	0.001
	Creative Thinking	0.213	0.000

Table 5 shows that the pretest data of the critical thinking ability of the Problem Based Learning class in the context of Batik Purworejo has a p-value = 0.200 > 0.05 which causes Ho to be accepted. So it can be concluded that the pretest data on class critical thinking skills with the Problem Based Learning learning model in the context of Purworejo Batik is distributed normally. The pretest data on creative thinking ability has a p-value = 0.200 > 0.05. This caused Ho to be accepted, so it can be concluded that the class critical thinking ability pretest data with the Problem Based Learning learning model in the context of Purworejo Batik is normally distributed.

Pretest data on class critical thinking skills with the Project Based Learning learning model in the context of Batik Purworejo critical thinking skills have a p-value of 0.085 > 0.05 which caused Ho to

be accepted. This means that the class critical thinking ability pretest data with the Project Based Learning learning model in the Purworejo Batik context is distributed normally.

The postest data of the class with the Problem Based Learning learning model in the context of Batik Purworejo has a p-value = 0.087 > 0.05. This shows that Ho was accepted so that it can be concluded that the distribution of data from the classroom with the Problem Based Learning learning model in the context of Batik Purworejo is normally distributed.

In data that has a p-value of < 0.05, the ratio of skewness and kurtosis can be calculated. Skewness is the level of distribution slope and is the level of data distribution slope. If the skewness ratio is at an interval of -1.96 ≤ (skewness ratio) ≤ 1.96 and the kurtosis ratio is at an interval of -1.96 ≤ (kurtosis ratio) ≤ 1.96 with a 95% confidence level, then the data is normally distributed. Calculate the ratio of skewness and kurtosis by dividing the value of each of these statistical values by std. Error. The results of the calculation are presented in tables 24 and 25.

Table 6. Skewness and Kurtosis Ratio Pretest

Class	Value	*Skewness*			*Kurtosis*		
		Stat	***Std.eror***	**Race**	**Stat**	***Std.Eror***	**Race**
Project Based Learning	Creative Thinking	0.239	0.414	0.58	-0.095	0.809	0.12

From table 6, it is known that the value of the skewness ratio of the results of the creative thinking ability pretest is 0.58 and the kurtosis ratio of the creative thinking ability pretest results is 0.12. The data shows that the data is distributed normally. So that it can be concluded for the class pretest data with the Project Based Learning learning model of the Purworejo Batik context on each variable in each class with a normal distribution.

Table 7. Ratio of Skewness and Postest Kurtosis

Class	Value	*Skewness*			*Kurtosis*		
		Stat	***Std.eror***	**Race**	**Stat**	***Std.eror***	**Race**
Problem Based Learning	Creative Thinking	-0.789	0.414	-1.90	-0.039	0.809	-0.048
Project Based Learning	Critical Thinking	-2.669	0.414	-6.44	9.392	0.809	11,6
	Creative thinking	-1,.705	0.414	-4,12	6.512	0.809	8.05

From table 7, it is known that the value of the skewness ratio of the postest creative thinking ability of the Problem Based Learning class in the Purworejo batik context is -1.90 and the kurtosis ratio value is -0.048. The data shows that the data is distributed normally.

The results of the postest class with the Project Based Learning learning model in the context of Batik Purworejo the ability to think critically showed a skewness ratio of -6.44 and a kurtosis ratio of 11.6. The data shows that the data on class critical thinking skills with the Project Based Learnimg model in the context of Batik Purworejo shows that the data is not distributed normally.

The results of the postest class with the Project Based Learning learning model in the context of Batik Purworejo the ability to think creatively showed a skewness ratio of -4.12 and a kurtosis ratio of 8.05. The data shows that the data on the creative thinking ability of the class with the Project Based Learnimg model in the context of Batik Purworejo shows that the data is not distributed normally univariate. The results of the pretest and posttest data normality test for each class can be summarized in the following table.

Table 8. Univariate normality test results.

Class	Variabel	*Pretest*	*Postest*
Problem Based Learning	Critical Thinking	Normal	Normal
	Creative Thinking	Normal	Normal
Project Based Learning	Critical thinking	Normal	Abnormal
	Creative Thinking	Normal	Abnormal

The normality assumption test will later be used for the next test. Data that are normally distributed will be tested using parametric statistics, while data that is abnormal in the follow-up test will be used are non-parametric statistics.

3) Multivariate Homogeneity Test

Multivariate homogeneity tests are carried out to find out if the class comes from homogeneous data. Multivariate homogeneity testing was carried out using the Box-M test. The significance level used in this study is 0.05. If the p-value > 0.05 then H0 is accepted which means the matrix of variance and covariance of the two homogeneous classes. The test hypothesis used is as follows.
H0: the covariance matrix of the two homogeneous experimental classes
H1: the covariance matrix of the two experimental classes is not homogeneous
The homogeneity test was carried out on the postest results and produced data according to the table below.

Table 9. Box-M Test Results

Data	Box-M	F	df1	df2	Itself.
Pretest	15.207	4.892	3	691920.000	0.002
Postest	11.313	3.639	3	691920.000	0.012

The significance value generated to the pretest results results results in a p-value of 0.002 < 0.05 so that H0 is rejected which means that the matrix of variance and covariance of the two classes is not homogeneous. Then for the significance value produced on the postest result, a p-value of 0.012 < 0.05 is produced so that H0 is rejected which means that the matrix of variance and covariance of the two classes is not homogeneous.

4) Univariate Homogeneity Test

A univariate homogeneity test was also carried out to see the class data of each variable from a homogeneous class. Homogeneity testing is performed using the Lavene test. The homogeneity test and the conclusion drawn on the hypothesis test used a significance level of 0.05. If the value of significance (probability) produced is more than 0.05, then H0 is accepted which means that the variance-covariance matrix in both classes is equal or homogeneous. The test hypotheses in this study are as follows.
H0: Population variance of both homogeneous classes
H1: Population variance of both classes is not homogeneous
The results of the homogeneity test on each variable are presented in the following table 28.

Table 10. Homogeneity Test

Data	Variabel	F	*p-value*	Conclusion
Pretest	Critical Thinking	1.873	0.176	Homogeneous
	Creative Thinking	0.577	0.450	Homogeneous
Postest	Critical Thinking	32.204	0.000	Not Homogeneous
	Creative Thinking	0.035	0.853	Homogeneous

Analysis of the Effectiveness of Problem Based Learning and Project Based Learning Models in the Context of Batik Tulis Kebumen, Reviewed from the Ability to Think Critically and Creatively Think

1) Test the effectiveness of the Problem Based Learning Model in the context of Batik Purworejo

The first hypothesis in this study is that the Problem Based Learning learning model in the context of Batik Purworejo is effective from the perspective of critical and creative thinking skills. The assumption test showed pretest and posttest data on both abilities in the classroom with the Problem Based Learning learning model in the context of Batik Purworejo showed normal distributed data, then hypothesis testing using parametric statistics using the one sample t-test using the help of SPSS for windows 25 trial version. The hypothesis used is as follows.
Ho: m1≤ 74.99 Classes with the Problem Based Learning learning model in the context of Batik Purworejo are effectively reviewed from the ability to think critically
H1: m1> 74.99 Classes with the Problem Based Learning learning model in the context of Batik Purworejo are not effective from the perspective of critical thinking skills
Ho: m3 ≤ 74.99 Classes with the Problem Based Learning learning model in the context of Batik Purworejo are effectively reviewed from the ability to think creatively
H1: m3> 74.99 Classes with the Problem Based Learning learning model in the context of Batik Purworejo are not effective from the perspective of creative thinking skills

The results of the one sample t-test are presented in the following table.

Table 11. One sample t-test results

Variabel	N	Average	T Count	*p-value*
Critical Thinking	32	80.41	2.541	0.016
Creative Thinking	32	72.19	-1.557	0.130

In table 11, the variable of critical thinking ability has a t-value = 2.541 with a p-value of 0.016 < 0.05 which causes Ho to be accepted, which means that the Problem Based Learning learning model in the context of Batik Purworejo is effectively reviewed from the critical thinking ability. The variable of creative thinking ability has a t-value of -1.557 with a p-value of 0.130 > 0.05 so that Ho is rejected, which means that the Problem Based Learning learning model in the context of Batik Purworejo is not effective from the perspective of creative thinking skills.

2) Test the effectiveness of the Project Based Learning Model in the Purworejo Batik Context

The second hypothesis in this study is that the Project Based Learning learning model in the context of Batik Purworejo is effective from the ability to think critically and creatively. The assumption test showed that the postest data on critical and creative thinking skills were not normally distributed, so the hypothesis test used non-parametric statistics, namely by looking at the N-Gain Score with the help of the SPSS for windows 25 trial version. The data used is the postest data compared to the pretest data. The hypothesis used is as follows.

Ho: m2 ≤ 74.99 Classes with the Project Based Learning learning model in the context of Purworejo Batik are effectively reviewed from the ability to think critically

H1: m2> 74.99 Classes with the Project Based Learning learning model in the context of Batik Purworejo are not effective from the perspective of critical thinking skills

Ho: m4 ≤ 74.99 Classes with the Project Based Learning learning model in the context of Batik Purworejo are effectively reviewed from the ability to think creatively

H1: m4> 74.99 Classes with the Project Based Learning learning model in the context of Batik Purworejo are not effective from the perspective of creative thinking skills

The results of the N-Gain test are presented in the following table.

Table 12. N-Gain Test

Variabel	**Average *N-Gain***	**Minimum**	**Maximum**
Critical Thinking	71.60%	33.33%	86.11%
Creative Thinking	70.82%	34.18%	87.34%

The average percentage of N-Gain Score of class critical thinking ability with the Purworejo batik context-Based Learning learning model shows 71.60% according to the criteria for interpreting the effectiveness of N-Gain is included in the criteria of being quite effective, so it can be concluded that the Purworejo batik context-based learning model is effective in improving critical thinking skills. The average percentage of N-Gain Score of creative thinking ability in the classroom with the Purworejo batik context's Project Based Learning learning model shows 70.82% according to the criteria for interpreting the effectiveness of N-Gain is included in the criteria of being quite effective, so it can be concluded that the Purworejo batik context's Project Based Learning learning model is effective in improving creative thinking skills.

Analysis of the Difference in the Effectiveness of the Problem Based Learning and Project Based Learning Models in the Purworejo Batik Context Reviewed from the Ability to Think Critically and Creatively Think

After the test of normality and homogeneity assumptions was carried out in a multivariate manner, it was found that the data were not normally distributed and were not homogeneous in a multivariate manner. Therefore, to test the difference in the average of the two learning model classes, a non-parametric test will be used, namely the Wilcoxon sign rank test.

1) Average Difference Test Before Treatment

The hypothesis used in the average difference test before treatment is as follows.

H0: there is no difference in the ability to think critically and creatively think in the classroom which will be carried out with the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo

H1: There are differences in the ability to think critically and creatively think in the classroom which will be carried out with the Problem Based Learning learning model in the context of Purworejo Batik and Project Based Learning in the context of Purworejo batik.

The Wilcoxon sign rank test test data pretest showed a sig value. 0.103 > 0.05 which causes H0 to be accepted. This means that there is no significant difference between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo reviewed from the critical thinking and creative thinking of students. This means that the initial ability of each student in both classes is the same.

2) Mean Difference Test After Treatment

The postest results data were tested for effectiveness using non-parametric statistics. The hypothesis used in the mean difference test is as follows.

H0 : there is no difference in effectiveness between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo reviewed from critical thinking and creative thinking.

H1: There is a difference in effectiveness between the Project Based Learning learning model in the context of Batik Purworejo and Problem Based Learning in the context of Batik Puworejo reviewed from critical thinking and creative thinking.

The Wilcoxon sign rank test postest value shows a sig value. 0.00 < 0.05 which causes H0 to be rejected. This means that there is a significant difference between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo reviewed from critical thinking and creative thinking, so further testing is needed.

3) Further Test

The follow-up test aims to find out the differences between each learning model and each variable. The test was carried out using non-parametric statistics of the Mann Whitney U Test with the help of the trial version of SPSS 25 software. The results of the Mann Whitney U Test on each variable showed the following results.

Table 13. Mann Whitney U Test results

Variabel	Learning Model	Mean Rank	*p-value*
Critical thinking	PBL Batik	20.56	0.000
	PJBL Batik	44.44	
Creative thinking	PBL Batik	31.86	0.781
	PJBL Batik	33.14	

The hypotheses used for further testing of critical thinking skills are as follows.

H0: there is no difference in effectiveness between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo reviewed from a critical thinking perspective.

H1: there is a difference in effectiveness between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo reviewed from critical thinking.

In the results of the critical thinking ability postes, the statistical results show that critical thinking skills show a p-value of 0.000 < 0.05 so that H0 is rejected, which means that there is a significant difference in critical thinking skills. The postest results of creative thinking ability showed that the value of the mean rank of the class taught using the Project Based Learning learning model with the context of Purworejo batik 44.44 was greater than the mean range value of the class applied by the Problem Based Learning learning model in the context of Batik Purworejo, which was 20.56. This shows that the ranking of the results of the postes shows that the critical thinking skills of the Project Based Learning class in the context of Batik Purworejo are more effective in improving students' critical thinking skills.

The hypothesis used for further testing of creative thinking skills is as follows.

H0: there is no difference in effectiveness between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo reviewed from creative thinking.

H1: there is a difference in effectiveness between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo from a creative perspective.

The postest results of creative thinking ability showed a p-value of 0.781 > 0.05 so that H0 was accepted, which means that the postest results of creative thinking skills did not show a significant difference. However, descriptively, the value of the mean rank of Project Based Learning in the context of Purworejo batik 33.14 is greater than the mean range value of the class applied by the Problem Based Learning learning model in the context of Batik Purworejo 31.86. This shows that the ranking of the results of the postes of the creative thinking ability of the Project Based Learning class in the context of Batik Purworejo is no more effective in improving students' critical thinking skills even with insignificant differences.

This research was carried out by researching two classes, namely the experimental class and the control class, this research is known as quasi experiment. The experimental class applied the Project Based Learning learning model in the Purworejo batik context and the control class applied the Problem Based Learning learning model in the Purworejo batik context. The implementation of the research took place at SMP Negeri 2 Purworejo with a population of all grade IX students at SMP Negeri Purworejo. The purpose of this research is to see the effectiveness of the Problem Based Learning learning model in the Purworejo batik context and the Project Based Learning learning model in the Purworejo batik context on students' critical and creative thinking skills in solving mathematics problems.

1. The effectiveness of the Problem Based Learning learning model in the context of Purworejo batik

The results of the study show the effectiveness of the learning model on each of its bound variables, namely the ability to think critically and creatively in solving mathematical problems. Based on the research hypothesis, the results of the hypothesis test will be described as follows.

a. The Problem Based Learning learning model in the Purworejo batik context is effective in improving students' critical thinking skills
b. The Problem Based Learning learning model in the Purworejo batik context is not effective in improving students' creative thinking skills.

After a one-sample t-test was carried out on the results of the class postes with the Problem Based Learning learning model in the Purworejo batik context, it produced a t-table value of 2,541 and a p-value of 0.016 < 0.05 which caused Ho to be rejected, which means that the Problem Based Learning learning model in the Purworejo Batik context is effective from the point of view of critical thinking skills.

The variable of creative thinking ability has a t-value of -1.557 with a p-value of 0.130 > 0.05 so that Ho is accepted, which means that the Problem Based Learning learning model in the context of Batik Purworejo is not effective from the perspective of creative thinking ability. The ineffectiveness of the Problem Based Learning learning model in the context of Batik Purworejo occurs because at the time of the LKPD work there are still many students who are confused in solving existing problems so that the learning process is not achieved optimally. Limited time in the implementation of learning also affects the results obtained. Although it is said to be ineffective, there was an increase in the pretest results by 25.47 to 72.19 in the posttest results.

2. The effectiveness of the Project Based Learning learning model in the context of Purworejo batik

The results of the study tested the effectiveness of the Project Based Learning learning model in the Purworejo batik context on the ability to think critically and creatively. Based on the research hypothesis, the results of the hypothesis test will be described as follows.

a. The Purworejo batik context's Project Based Learning learning model is effective in improving students' critical thinking skills.
b. The Project Based Learning learning model in the Purworejo batik context is effective in improving students' creative thinking skills.

The assumption test showed that the posttest data of critical and creative thinking ability showed that the data was not normally distributed, so the hypothesis test used non-parametric statistics, namely by looking at the N-Gain Score from the pretest and posttest data of each variable. The average percentage of N-Gain Score of class critical thinking skills with the Purworejo batik context Project Based Learning learning model shows 71.60% according to the criteria for interpreting the effectiveness of N-Gain is included in the criteria of being quite effective in improving critical thinking skills.

The average percentage of N-Gain Score of creative thinking ability in the classroom with the Purworejo batik context's Project Based Learning learning model shows 70.82% according to the criteria for interpreting the effectiveness of N-Gain is included in the criteria of being quite effective, so it can be concluded that the Purworejo batik context's Project Based Learning learning model is effective in improving creative thinking skills.

3. Comparison of the effectiveness of the learning model

After testing the effectiveness of each learning model, testing and non-parametric statistics will be compared between the two learning models, testing with non-parametric statistics is carried out due to the abnormality of the research data results. The Wilcoxon sign rank test test data pretest showed a sig value. 0.103 > 0.05 which causes H0 to be accepted. This means that there is a significant difference between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo reviewed from critical thinking and creative thinking, so further testing is needed. This means that the initial ability of each student in both classes is the same.

The Wilcoxon sign rank test postest value shows a sig value. 0.00 < 0.05 which causes H0 to be rejected which means that there is a significant difference between the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo is reviewed from critical thinking and creative thinking so that further tests are needed to determine the effectiveness of each variable.

Further tests were carried out to see using the Mann Whitney test on the postest results of critical thinking ability. The results of the Mann Whitney test showed that critical thinking skills had a p-value of 0.000 < 0.05 so that H0 was rejected, which means that there is a significant difference in critical thinking skills between the two learning models. The postest results of creative thinking ability showed that the value of the mean rank of the class taught using the Project Based Learning learning model with the context of Purworejo batik 44.44 was greater than the mean range value of the class applied by the Problem Based Learning learning model in the context of Batik Purworejo, which was 20.56. This shows that in terms of the ranking of postest results, the critical thinking skills of the Project Based Learning class in the context of Batik Purworejo are more effective in improving students' critical thinking skills.

Whitney's Mann test on the postest results of creative thinking ability showed a p-value of 0.781 > 0.05 so that H0 was accepted, which means that the postest results of creative thinking skills did not show a significant difference. However, descriptively, the value of the mean rank of Project Based Learning in the context of Purworejo batik 33.14 is greater than the mean range value of the class applied by the Problem Based Learning learning model in the context of Batik Purworejo 31.86. This shows that the postest results of the creative thinking skills of the Project Based Learning class in the context of Purworejo Batik are better than the postest results of the creative thinking skills of the Problem Based Learning class of Purworejo batik. Even though the mean rank value of the PJBL Batik Purworejo class is higher than the PBL Batik Purworejo class according to the existing hypothesis, the Problem Based Learning learning model in the context of Batik Purworejo is no more effective than the Problem Based Learning learning model in the context of Batik Purworejo reviewed from the Creative Thinking Ability of junior high school students.

The results of the study have shown that the classes applied the Project Based Learning learning model with the context of Purworejo batik and Problem Based Learning with the context of Purworejo batik are effective in improving critical and creative thinking skills. The application of the Problem Based Learning model can improve critical thinking skills because students become more active and can use their thinking skills (Narmaditya et al, 2012). This can be concluded to also apply to the Project

Based Learning learning model because the activities in it adhere to the same understanding, namely constructivism. Activities in learning that are designed for students to build their own knowledge help them solve mathematical problems (Linda, 2015; Sarwoedi et al, 2018). The existence of problem-solving activities in learning activities, both in the Project Based Learning class with the context of Purworejo batik and Problem Based Learning with the context of Purworejo batik also helps students improve their critical thinking skills.

Activities in the Problem Based Learning learning model in the context of Batik Purworejo and Project Based Learning in the context of Batik Purworejo in dealing with problems such as asking questions, thinking about different ways to solve problems, and expressing conclusions to train students' creative thinking skills (Rohana & Wahyudin, 2017). In line with the previous statement, Mutuwally (2021:4) stated that Project Based Learning is able to encourage students' creativity to think critically and creatively.

CONCLUSION

The research findings indicate that the Problem-Based Learning (PBL) model in the context of Batik Purworejo is effective in enhancing the critical thinking abilities of junior high school students, as evidenced by a one-sample t-test showing a calculated t-value of 2.541 with a p-value of 0.016, thus rejecting the null hypothesis. In contrast, the Project-Based Learning (PjBL) model also proved effective, achieving an average N-Gain Score of 71.60%, indicating a sufficient effectiveness in improving critical thinking. However, the PBL model was found ineffective for fostering creative thinking, with a t-value of -1.557 and a p-value of 0.130, leading to the acceptance of the null hypothesis, although a notable improvement from a pretest score of 25.47 to a posttest score of 72.19 was observed. Conversely, the PjBL model significantly enhanced creative thinking, reflected by a 70.82% average N-Gain Score, affirming its effectiveness. Comparatively, the PjBL model was more effective than the PBL model in developing students' critical thinking, with a Mann-Whitney test showing a p-value of 0.000. The mean rank for the PjBL class was 44.44, surpassing the PBL class's mean rank of 20.56. Regarding creative thinking, the PBL model did not demonstrate greater effectiveness than the PBL model, with a p-value of 0.781 indicating no significant difference, although the mean rank for PjBL (33.14) was higher than that for PBL (31.86). These results imply that the PjBL model is more effective than the PBL model in enhancing both critical and creative thinking skills. Furthermore, both models promote student independence in constructing their knowledge and illustrate how real-world contextual problems can be integrated into classroom learning topics.

REFERENCES

Abdullah, I. H. (2013). Berpikir Kritis Matematik. Delta-Pi: Jurnal Matematika Dan Pendidikan Matematika, 2 (1), 66–75

Sinar, Sinar Ruslan, and Andi Asmawati Azis Asmawati. "Peningkatan Hasil Belajar Peserta Didik Menggunakan Project Based Learning (PjBL) pada Mata Pelajaran Biologi di SMA Negeri 2 Gowa." JURNAL PEMIKIRAN DAN PENGEMBANGAN PEMBELAJARAN 5, no. 2 (2023): 377-382.

Civil, M. (1995, July). Connecting home and school: Funds of knowledge for mathematics teaching. Makalah disajikan pada kelompok kerja untuk Cultural Aspects in the Learning of Mathematics, 19th International Conference for the Psychology of Mathematics Education

Setiawan, T., Sumilat, J. M., Paruntu, N. M., & Monigir, N. N. (2022). Analisis Penerapan Model Pembelajaran Project Based Learning dan Problem Based Learning pada Peserta Didik Sekolah Dasar. Jurnal Basicedu, 6(6), 9736-9744.

Prendergast, M., Faulkner, F., & O'Hara, C. 2016. The Effect of High Literacy
Demands in Mathematics on International Students. International Journal of
Educational Studies in Mathematics, 3 (2).

Akinoğlu, O., & Tandoğan, R. Ö. (2007). The Effects of Problem-Based Active Learning in Science Education on Students' Academic Achievement, Attitude and Concept Learning. Eurasia Journal of Mathematic

Trianto. (2018). Mendesain Model Pembelajaran Inovatif-Progresif.Jakarta: Kencana.

Abdulsyani.(1994). Sosiologi Skematika, Teori, dan Terapan. Jakarta: Bumi

Agustina, I. (2019). Pentingnya berpikir kritis dalam pembelajaran matematika di era revolusi industri 4.0. Jurnal Pendidikan Indonesia, 8(1), 1-9.

Ahmad Susanto .(2019). Teori Belajar & Pembelajaran di Sekolah dasar. Jakarta: Kencana Pradana Media Grup

Akcay, B. (2009). Problem-based learning in science education. Journal of Turkish science education, 6(1), 28-38.

Akhirudin, et al. (2019). Belajar dan Pembelajaran. Gowa: Cahaya Bintang Cemerlang

Amalia, R. N., Rochmad, R., & Kharis, M. (2019, February). Efektivitas Kemampuan Berpikir Kreatif Matematis Siswa Kelas VII pada Problem Based Learning Bertema. In PRISMA, Prosiding Seminar Nasional Matematika (Vol. 2, pp. 185-189).

Amelia, R., Aripin, U., & Hidayani, N. (2018). Analisis kemampuan berpikir kreatif matematik siswa smp pada materi segitiga dan segiempat. JPMI (Jurnal Pembelajaran Matematika Inovatif), 1(6), 1143-1154.

Amin, S., Utaya, S., Bachri, S., Sumarmi, & Susilo, S., (2020). Effect of problem-based learning on critical thinking skills and environmental attitude. Journal for the Education of Gifted Young Scientists, 8(2), 743-755. DOI: http://dx.doi.org/10.17478/jegys.650344

Anwar, F., Pajarianto, H., Herlina, E., Raharjo, T. D., Fajriyah, L., Astuti, I. A. D., ... & Suseni, K. A. (2022). Pengembangan Media Pembelajaran "Telaah Perspektif Pada Era Society 5.0". Makasar: TOHAR MEDIA

Aqib, Z., & Murtadlo, A. (2022). AZ Ensiklopedia Metode Pembelajaran Inovatif: Untuk Guru, Dosen, dan Mahasiswa. Yogyakarta: Penerbit Andi.

Arends, R. I. (2012). Learning to teach (Ninth Edition). In B. Mejia (Ed.), Mc Graw Hill (ninth, Vol. 4, Nomor 1). Mc Graw Hill.

Aris, shoimin. (2014). 68 Model Pembelajaran Inovatif dalam Kurikulum 2013. Yogyakarta: Ar- Ruzz Media

Aris, shoimin. (2014). Model Pembelajaran Inovatif dalam Kurikulum 2013. Yogyakarta: Ar- Ruzz Media

Ariyana, Yoki dkk, 2018. Pegangan Pembelajaran Berorientasi pada Keterampilan Berpikir Tingkat Tinggi, Jakarta: Dirjend GTK Kemdikbud.

Aslanides, C. D., Kalfa, V., Athanasiadou, S., Gianelos, Z., & Karapatsias, V.(2016). Advantages, Disadvantages and the Viability of Project-Based Learning Integration in Engineering Studies Curriculum: The Greek Case (1)(2)(3)(4)(5) Board of European Students of Technology (BEST) Aristotle. 44 th SEFI Conference, September, 12–1

Ati, T. P., & Setiawan, Y. (2020). Efektivitas Problem Based Learning -Problem Solving Terhadap Kemampuan Berpikir Kritis dalam Pembelajaran Matematika Siswa Kelas V. Jurnal Cendekia: Jurnal Pendidikan Matematika, 4(1), 294-303

Azwar, S. (2005). Dasar-Dasar Psikometri.Yogyakarta: Pustaka Pelajar.

Azwar,S. (2003). Penyusunan Skala Psikologi.Yogyakarta: Pustaka Belajar Campuran. Edisi .Yogyakarta : Pustaka pelajar

Balka, D. S. (1974). Using research in teaching: Creative ability in mathematics. The Arithmetic Teacher, 21(7), 633-636

Barell, J. (2010). Problem-based learning: The foundation for 21st century skills. 21st century skills: Rethinking how students learn, 175-199

Barell, J. F. (2006). Problem-based learning: An inquiry approach. Corwin Press.

Barrows, H. S., & Tamblyn, R. M. (1980). Problem-based learning: An approach to medical education (Vol. 1). Springer Publishing Company.

Bender, W. N. (2012). Project-based learning: Differentiating instruction for the 21st century. Corwin Press.

Boss, S., Larmer, J. (2018). Project Based Teaching: How to Create Rigorous and Engaging Learning Experiences. United States: ASCD.

Burton, W. H. (1962). The guidance of learning activities: A summary of the principles of teaching based on the growth of the learner. (No Title).

Cahyadi, D. (2023). Berpikir Lebih Kreatif dengan Menggunakan Nalar Logis: Konsep Berpikir Lateral dalam Berinovasi.

Chen, C., Hung, H., & Yeh, H. (2021). Virtual reality in problem-based learning contexts: Effects on the problem-solving performance, vocabulary acquisition and motivation of English language learners. Journal of Computer Assisted Learning. doi:10.1111/jcal.12528

Chiang, C. L., & Lee, H. (2016). The Effect of project-based learning on learning motivation and problem-solving ability of vocational high school students. International Journal of Information and Education Technology, 6(9), 709–712. https://doi.org/10.7763/ijiet.2016.v6.779

Cipta.Susilawati, Wati. (2020). Belajar dan Pembelajaran Matematika. Bandung: CV Insan Mandiri

Corazza, G. E., & Agnoli, S. (Eds.). (2016). Multidisciplinary contributions to the science of creative thinking. Singapore: Springer.

Cotrell, S. (2005). Critical thinking skills: Developing effective analysis and argument. Phalgrave Macmillan, New York, 250.

Cottrell, S. (2005). Palgrave study skills. Critical thinking skills. Hampshire: Palgrave Macmillan.

Damayanti, D., & Magdalena, I. (2021). Jago Mendesain Pembelajaran (untuk Guru Sekolah Dasar). Bogor: Guapedia

Daniel, Farida. (2017). Kemampuan Berpikir Kritis Siswa Pada Implementasi Project Based Learning (PJBL) Berpendekatan Saintifik. JPMI (Jurnal Pendidikan Matematika Indonesia). 1. 7. 10.26737/jpmi.v1i1.76.

Darwanto, D. (2019). Kemampuan Berpikir Kreatif Matematis: (Pengertian dan Indikatornya). Eksponen,9(2),20–26.https://doi.org/10.47637/eksponen.v9i2.56

De Graaf, E., & Kolmos, A. (2003). Characteristics of problem-based learning. International journal of engineering education, 19(5), 657-662.

Dea, W. A., & Rahmawati, T. D. (2021). Penerapan Model Project Based Learning Untuk Meningkatkan Kemampuan Berpikir Kreatif Matematika Peserta Didik. RANGE: Jurnal Pendidikan Matematika, 2(2), 141-148.

Dea, W. A., & RAHMAWATI, T. D. (2021). Penerapan Model Project Based Learning untuk Meningkatkan Kemampuan Berpikir Kreatif Matematika Peserta Didik. RANGE: Jurnal Pendidikan Matematika, 2(2), 141-148.

Deborah E. Allen; Richard S. Donham; Stephen A. Bernhardt (2011). Problem-based learning. DOI:10.1002/tl.465 EdTechBooks. https://edtechbooks.org/studentguide diakses pada tanggal 8 April 2023

Dochy, F., Segers, M., Bossche, P. V. D., & Struyven, K. (2005). Students' Perceptions of a Problem-Based Learning Environment. Learning Environments Research, 8(1), 41–66. https://doi.org/10.1007/s10984-005-7948-x

Dolmans, D. H., Loyens, S. M., Marcq, H., & Gijbels, D. (2016). Deep and surface learning in problem-based learning: a review of the literature. Advances in health sciences education, 21, 1087-1112.