Effect of Project-Based Learning (PjBL) Model Assisted by Geospatial Technology on Students' Creative Thinking Skills

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Abstract: In the era of globalization and technological developments, education plays an important role in preparing students' future. One of the geospatial technologies that can be utilized is Google Earth, which allows students to access spatial information visually and interactively. Teachers need to use the Project Based Learning (PjBL) learning model to determine the effect of students' creative thinking skills. This study examines the effect of a project-based learning model supported by geospatial technology on the creative thinking skills of grade X students at SMAN 2 Batu. The method used was a quasi-experiment with a post-test-only control group design. Students of class X5 became the experimental class that applied the PjBL model, while class X6 was a control with conventional learning. The results showed that the mean value of the creative thinking skills post-test was higher (84.84) compared to the control class (74.00). The results of hypothesis testing using the Mann-Whitney U-Test non-parametric test showed Sig. (2-tailed) 0.000<0.05, which indicates a significant difference in the post-test scores of the two classes, which means that the hypothesis (H0) is rejected and the hypothesis (Ha) is accepted, so it can be concluded that the application of the Project Based Learning (PjBL) model assisted by geospatial technology has a significant effect on students' creative thinking skills.

Abstrak: Dalam era globalisasi dan perkembangan teknologi pendidikan memiliki peranan penting dalam menyiapkan masa depan siswa. Salah satu teknologi geospasial yang dapat dimanfaatkan seperti *Google earth*, yang memungkinkan siswa untuk mengakses informasi keruangan secara visual dan interaktif. Untuk mengetahui pengaruh keterampilan berpikir kreatif siswa, guru perlu menggunakan model pembelajaran *Project Based Learning* (PjBL). Penelitian ini bertujuan untuk mengkaji pengaruh model pembelajaran berbasis projek yang didukung oleh teknologi geospasial terhadap keterampilan berpikir kreatif siswa kelas X di SMAN 2 Batu. Metode yang digunakan adalah eksperimen semu dengan desain *post-test only control group*. Siswa kelas X5 menjadi kelas eksperimen yang menerapkan model PjBL, sedangkan kelas X6 sebagai kontrol dengan pembelajaran konvensional. Pada hasil penelitian didapatkan nilai rerata *post-test* keterampilan berpikir kreatif lebih tinggi (84,84) dibandingkan dengan kelas kontrol (74,00). Hasil uji hipotesis menggunakan uji non parametrik *Mann-Whitney U-Test* yang menunjukkan hasil Sig. *(2-tailed)* 0.000<0.05, yang mengindikasikan adanya perbedaan signifikan pada nilai *post-test* kedua kelas, yang berarti hipotesis (H0) ditolak dan hipotesis (Ha) diterima, sehingga dapat disimpulkan bahwa penerapan model *Project Based Learning* (PjBL) berbantuan teknologi geospasial berpengaruh signifikan terhadap keterampilan berpikir kreatif siswa.

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A. Introduction

In the era of globalization and the rapid development of information technology, education has an important role in preparing students for their future. In the 21st century, technology is developing rapidly, which supports the quality of education. However, this is also a challenge for teachers because teachers must master the technology used during learning. Technology in education has opened the door to producing more interactive and engaging learning models; nowadays, technology cannot be separated from the learning process. The era of globalization provides many changes, especially in the development of technology and information communication. To deal with this, the implementation and adaptation of technology in learning is a must that must be done (Effendi & Wahidy, 2019)

One of the uses of technology as a medium for geography learning in schools is utilizing geospatial-assisted technology. Easy access to geospatial technology can be utilized well in learning. Geospatial technology is a space for presenting spatial and territorial information used to collect, analyze, and visualize data related to locations on the Earth's surface (Sejati, 2021). Geospatial technology allows students to view data through maps and three-dimensional models, which helps them understand the relationship between various elements in space (Tabbu et al., 2023). Spatial technology-assisted learning in learning is one of them, using Google Earth.

Google Earth can present geospheric phenomena in a particular area to give students a thorough understanding of the location of events (Mutia et al., 2023). Google Earth is a globe that produces virtual images that allow students to view the Earth's surface from various vantage points and perspectives (Salam et al., 2023). Learning needs to use non-monotonous media, and Google Earth can help students have creative thinking skills. Creativity results from human cognitive activity that reflects the ability to generate original, innovative, and valuable ideas. These creative ideas show novelty and practical relevance that can be applied in various social and cultural contexts. In addition, creativity has universal characteristics because it can be understood and accepted by various groups, so it has the potential to encourage the birth of new forms of creativity that are more complex and adaptive to the times (Zainuddin et al., 2023)

Google Earth has advantages in visualizing geospatial data. The features contained in Google Earth allow students to interact directly with maps and images (Gorelick et al., 2017). Google Earth has undergone many changes since its launch in 2001. It initially contained only a simple 3D display of the shape of the Earth's surface. However, it has developed various features, such as high-quality satellite imagery and the ability to view historical environments. In 2005, Google Earth added a search feature that made it easier for users to find specific locations. It was then developed again in 2017 by launching a voyager feature that provides features for users to explore various places around the world (Barreau, 2025). In addition, there is also a time-lapse feature that allows users to see changes in the Earth's surface over several decades. Using Google Earth, students can do visual exploration, such as mountains, rivers, and cities, in a more realistic context. Learning involving students like this creates more

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fun interactions and an enjoyable learning process, encouraging curiosity and formulating new ideas that produce creative thinking skills (Purwaningrum, 2016).

To foster creative thinking skills through Project-Based Learning (PjBL), it is essential to provide learning media that align with the characteristics of PjBL. The right media not only facilitates students in doing projects but also stimulates them to combine various perspectives, procedures, and environmental conditions to create meaningful new ideas. According to (Chepy, 2016), creativity arises when students can synergize these elements to produce original concepts applicable to the learning context. According to (Utami et al., 2015), students' creative thinking skills can be seen from 4 main aspects, namely: 1) the ability to generate unique ideas, 2) flexibility in moving between various approaches, 3) fluency in generating many ideas in a short time, and 4) as well as skills in developing and enriching one basic idea until a mature idea is realized.

On the other hand, according to (Suripah & Sthephani, 2017), creative characteristics involve not only the cognitive domain but also non-cognitive aspects. The cognitive domain includes the four creative thinking indicators: fluency, flexibility, originality, and elaboration. In contrast, the non-cognitive domain includes motivation, personality traits, and attitudes that support the creative process. Although every student has high creative potential, in reality, many students have not been able to channel it optimally. Their innovative talents are often challenging to hone without the support of the right media and PjBL strategies. Therefore, educators must choose and design learning media that not only present content but also trigger curiosity, freedom of experimentation, and collaboration so that student creativity is truly explored and developed during the learning process.

Creative thinking skills can be implemented by students in everyday life to see the effect of students' skills in creative thinking. Therefore, teachers must develop learning models that are considered to influence the level of innovation and creativity of students. The learning model that can influence student's creative thinking skills, especially in creating a product, is the project-based learning (PjBL) model. The PjBL learning model is one of the learner-oriented learning approaches that emphasize active involvement in the design, implementation, and evaluation of projects related to problems in the surrounding environment, and this approach provides flexibility for teachers in managing the learning process (Octariani & Rambe, 2020). The PjBL learning model affects student engagement, especially creativity, due to the learning process directly involved with the project (Dole et al., 2017).

PjBL encourages students to be actively involved in the learning process. By being directly involved in the project, students function as recipients of information and take on the role of idea initiators, planners, and implementers (Ramadhan & Hindun, 2023). Students' involvement in this learning increases their sense of responsibility for learning and stimulates curiosity and imagination, which are important components of creative thinking. The characteristics of the learning model (PjBL) are: 1) the teacher acts as a facilitator who guides the learning process and as an evaluator of the products produced by students; 2) PjBL makes the project as the primary tool in the learning process; 3) Learning begins with

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problems that come from the context of students' real lives; 4) This approach emphasizes the importance of contextual learning, which is relevant to the experience and environment of students; and 5) Students can produce simple projects that reflect their understanding of the material that has been learned (Utami et al., 2015)

The PjBL model consists of 6 steps, namely 1) making the main project question, 2) designing the project as a whole, 3) scheduling project stages, 4) monitoring project progress continuously, 5) presenting project results, 6) evaluating project results (Dole et al., 2017). The Project Based Learning (PjBL) learning model substantially integrates the principles of 21st-century skills known as 4C, namely critical thinking, communication, collaboration, and creativity (Sukmanasa et al., 2023)

Research states that Project-Based Learning (PjBL) influences students' creative thinking skills through active involvement in various project stages. Similar findings came from the study (Syahwifa & Wijayanto, 2025), which showed the PjBL model's effectiveness in fostering students' innovation and creative thinking skills. Both studies indicated that the PjBL model significantly influenced students' creative thinking skills. This research also highlights the importance of using geospatial technology in project-based learning. Creative thinking skills need to be applied in learning to deal with problems in everyday life with the help of geospatial technology. However, in practice, creative thinking skills and the utilization of geospatial technology are still relatively low. Seeing this urgency, the researcher carried out research activities to examine the effect of the PjBL model assisted by geospatial technology on students' creative thinking skills in class X at SMAN 2 Batu.

Based on these conditions, this research explores how the PjBL model enriched with geospatial technology can influence the creative thinking skills of grade X students at SMAN 2 Batu. Although PjBL has been adopted in various subjects, its application, specifically in geography learning at this school, has never been studied. The need for studies that combine contextual, innovative, and relevant approaches to the demands of the 21st century becomes the primary foundation, so the results of the study are expected to not only fill the void of literature but also provide practical guidance for educators to design more dynamic and meaningful learning models.

B. Method

This study used a quantitative approach with a quasi-experiment to test the effect of PjBL on students' creative thinking skills. 8 X classes at SMAN 2 Batu were used as the population. Then, samples were taken randomly so that two classes were obtained with almost the exact characteristics of the average daily test scores. The measurement of creative thinking skills was carried out after treatment with Post Test Only Control Group Design so that the results between the two groups could be seen directly when applying the PjBL model (Rati et al., 2017). The research design is as follows:

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Table 1. Design Post Test Only Control Group Design

Class	Treatment	Post-test
Experiment	X_1	O_1
Control	X_2	O_2

Description :

X_1 : Experimental class treatment with PjBL model assisted by geospatial technology

X_2 : Treatment of the control class with a conventional model

O_1 : *Post-test* in the experimental class

O_2 : *Post-test* in control class

Class X5 was selected as the experimental group and class X6 as the control group, each with 36 students. In the experimental class, the PjBL model assisted by geospatial technology, namely Google Earth, was applied, and in the control class, a conventional learning model was carried out. After the treatment, a post-test was conducted to measure the effect of students' creative thinking skills. Data collection was carried out using creative thinking skills test techniques. The instrument used to measure creative thinking skills uses four essay questions, each representing each indicator of creative thinking skills.

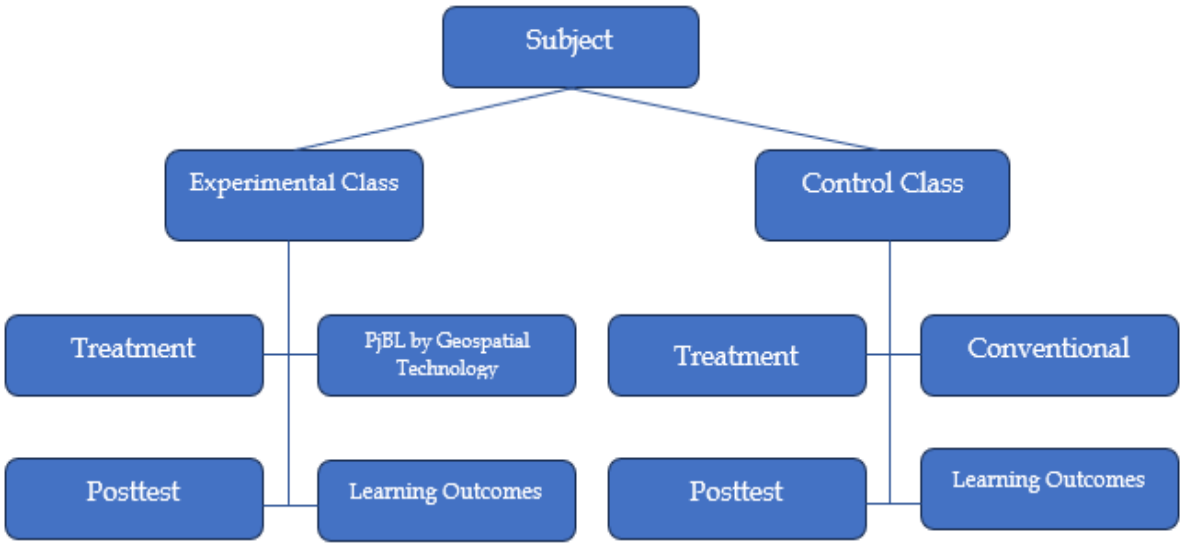

Figure 1. Research Design Flow

The test instrument has been tested for validity, and the validity test of the instrument uses Pearson correlation analysis, which shows a sig value <0.05 so that the question is declared valid. In contrast, the reliability test uses Cronbach's alpha, with a significance level of 0.641>0.60, to declare the instrument reliable. The first stage carried out in data analysis is a prerequisite test with a normality test using Kolmogorov-Smirnov, and then there is a homogeneity test using Levene's based on the normality and homogeneity tests that have been carried out; it is found that the data is not normally distributed but is homogeneous. The results of data processing carried out indicate that the values of the two

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classes are generally not distributed; in the experimental class, the value is 0.000 <0.05, and in the control class, the value is 0.001 <0.05, which indicates that the two classes do not meet the assumptions of normality. However, in the homogeneity test, the results were 0.842>0.05. This indicates that the variance of the two classes is considered homogeneous. However, neither prerequisite test meets the hypothesis test because there is abnormal data from the prerequisite test. Alternative hypothesis testing uses a non-parametric test, namely the Mann-Whitney U-Test.

Hypothesis testing using the Mann-Whitney U-Test non-parametric test aims to compare two independent groups between the control and experimental classes. The result of this test is determined by the significance value of Asymp (p-value); if the value is <0.05, then H0 is rejected, and Ha is accepted. Conversely, if > 0.05, H0 is accepted, and Ha is rejected. The results showed a significant effect of the PjBL model assisted by spatial technology on students' creative thinking skills related to remote sensing. As another alternative to testing the hypothesis, this study applied the Mann-Whitney U-Test, a non-parametric test designed to compare two independent groups, namely the experimental and control classes. The aim is to assess whether the two groups significantly differ in creative thinking ability. According to (Murniati et al., 2013), if the Asymptotic significance value (Asymp.) < 0.05, then the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted and vice versa, when the value of Asymp. > 0.05, Ha is accepted. The analysis results show that applying the PjBL model assisted by spatial technology significantly affects students' creative thinking skills in remote sensing material.

C. Result and Discussion

Result

The research conducted at SMAN 2 Batu was conducted three times. The effect of students' creative thinking skills was measured using essay test questions. The post-test in this study was carried out at the third meeting; the post-test was given to the experimental and control classes.

Table 2. Category of Experimental & Control Class Grades

Category	Value Range	Experiment Class%	Control Class%
Very good	85-100	68	8
Good	70-84	27	64
Simply	55-69	5	28
Less	>55	-	-

Based on the data in Table 2, the analysis results showed a significant difference between the experimental and control classes regarding students' creative thinking skills. In the experimental class, 68% of the students showed creative thinking skills in the excellent category, indicating a remarkable achievement in their creative thinking ability. In addition, 27% of students were in the good category, while the remaining 5% were recorded in the

https://doi.org/10.51276/edu.v6i2.1271

fair category. On the other hand, the results in the control class showed a pretty striking difference. Only 8% of students scored in the excellent category, while the majority, 64%, were in the good category, and the remaining 28% were recorded in the fair category.

Based on the predetermined creative thinking skills assessment categories, the post-test results showed a clear difference between the two groups studied. The experimental class's average post-test score of students' creative thinking skills was 84.84, while the control class only reached 74.00. This comparison indicates that students in the experimental class showed higher creative thinking skills achievement than those in the control class. The data of students' creative thinking skills post-test results are presented in Table 3.

Table 3. Post-Test of Students' Creative Thinking Skills

	N	Minimum	Maximum	Mean
Eksperiment	36	68	93	84.84
Control	36	62	93	74.00
Valid N (listwise)	36			

The average value of the experimental class post-test results showed a significant effect on students' creative thinking skills after applying the project-based learning method. The value description is presented in Table 4.

Table 4. Test Scores for Each Indicator of Creative Thinking Skills

Indicators Skills Creative Thinking	Posttest Experiment Class	Posttest Control Class	Difference
Fluency	79.75	71.5	8.25
Flexibility	89.5	80.5	9
Originality	84.72	73	11.72
Elaboration	85.41	71	14.41
Average	84.84	74.00	

The indicators of creative thinking skills that students must achieve are fluency, flexibility, originality, and elaboration. Table 4 shows that the average post-test of creative thinking skills for each indicator of the two classes shows the highest difference of 14.41, namely the elaboration indicator. This shows differences in students in the two classes who can develop and expand their ideas. This is undoubtedly related to the learning model in both classes, namely PjBL, which allows students to explore their ideas more in-depth (Mukti et al., 2020). Furthermore, there is an indicator of originality, which has a difference of 11.72, where there are differences between the two classes in answering questions with their thoughts. The originality indicator in creative thinking skills measures how students can generate unique, new, and innovative ideas. This indicator reflects students' ability to think outside the box and create solutions or ideas that are different from those that have existed before (Safitri et al., 2023).

https://doi.org/10.51276/edu.v6i2.1271

The difference between the two classes occurred due to differences in students' ability to see a problem from various points of view and produce solutions from various other alternative ideas (Zakiah et al., 2020). The indicator that has the lowest score difference is fluency. This shows a difference between the experimental and control classes in students' ability to generate many ideas quickly (Tsai et al., 2017). The fluency indicator measures the extent to which students can provide a variety of ideas or solutions without hindrance in a short time. Provide a variety of ideas or solutions without hindrance in a short time.

After collecting the post-test data, the next step was ensuring that the statistical requirements were met before hypothesis testing. First, the normality test was conducted with Kolmogorov-Smirnov using SPSS version 23 at a significance level of α = 0.05. This method was chosen because each sample group consisted of more than 50 students (Oktaviani & Notobroto, 2015). The results showed that only the control group had a significance value above 0.05, meaning the data distribution was normal. In contrast, the normality assumption was not met in the experimental group.

Furthermore, the variance homogeneity test was conducted using Levene's test method in SPSS 23 with the criterion α = 0.05. Data is declared homogeneous when the significance value exceeds 0.05, which is also proven in this study. However, since the overall distribution of the data did not meet the assumption of normality, it did not qualify for hypothesis testing. Therefore, an alternative test used a non-parametric approach by applying the Mann-Whitney U Test, which does not require normal data distribution and is more suitable for comparing two independent groups under these conditions.

Table 5. Mann-Whitney U-Test of Creative Thinking Skills

Mann-Whitney Test				
Ranks				
	Class	N	Mean	Sum of Ranks
Creative Thinking Skill	Experiment	36	47.69	1717.00
	Control	36	23.97	839.00
	Total	72		
			Creative Thinking Skill	
Mann-Whitney U			209.000	
Wilcoxon W			839.000	
Z			-4,968	
Asymp.Sig. (2-tailed)			0.000	

The results of hypothesis testing using the Mann-Whitney U-Test showed a Z statistical value of -4.968, which indicated that the experimental group had a higher level of creative thinking skills than the control group. In addition, the significance value (Asymp. Sig.) obtained of 0.000 is far below the significance threshold of α = 0.05, which means that the difference between the two groups is statistically significant. Based on these results, the

https://doi.org/10.51276/edu.v6i2.1271

decision taken in the hypothesis test is to reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1). Thus, it can be concluded that there is a significant effect of applying the Project Based Learning (PjBL) model assisted by geospatial technology on students' creative thinking skills.

Discussion

The application of the PjBL (Project Based Learning) model assisted by spatial technology in the experimental class had a significant effect on students' creative thinking skills. The stages of the PjBL model that researchers carried out in the experimental class were in line with the stages of the PjBL model (Kemdikbud, 2014), namely 1) determining fundamental questions, 2) designing project planning, 3) preparing schedules, 4) monitoring students and project progress, 5) testing results, 6) evaluating experiences. In the first stage, researchers provide basic questions that refer to problems in the surrounding environment, which cannot be separated from remote sensing material. At this stage, students have different points of view on how to answer a problem (Syahwifa & Wijayanto, 2025). Indirectly, this stage applies the originality indicator to students' creative thinking skills. Students provide ideas about the problems using Google Earth as a spatial technology for analyzing land changes, which are included in remote sensing material. Students will provide answers according to their point of view (Ratinen & Keinonen, 2011). Students will provide creative solution ideas to a problem.

In the second phase, teachers and students collaboratively developed the project framework. Students were divided into six teams, each with six members, in experimental and control classes, creating six groups with 36 participants. Each group was given a different case study, where they utilized Google Earth as a geospatial technology to observe and analyze the problem given by the teacher. After the project framework and the tasks of each team were agreed upon, the teacher and students set a 2-week implementation schedule to complete the entire set of project activities. At this stage, Google Earth media is important for the project's sustainability. With Google Earth, students can observe changes in land use or specific geographic areas based on satellite imagery. Using historical features can also help students explore land changes from year to year (Ali et al., 2024). This aligns with the remote sensing concept, which utilizes data from remote sensors to understand phenomena on the Earth's surface (Ramadhan, 2022). At this stage, it can be related to the elaboration indicator of creative thinking skills. This indicator reflects students' ability to develop ideas in depth and provide complete details in their thinking.

The third stage is the scheduling stage, in which students and teachers work together to develop a structured schedule to ensure the project goes according to plan. The division of tasks for each individual in a group must also be done fairly. In the image interpretation project with land change analysis, this stage includes determining the time to download and analyze satellite images with the help of Google Earth, interpreting images, and delineating land change areas. Within 2 weeks, students are expected to complete the project. The next stage is monitoring the results and progress of the project. The teacher plays an active role as

https://doi.org/10.51276/edu.v6i2.1271

a facilitator by monitoring each process to ensure that students remain focused on the project objectives and can deal with various obstacles that arise (Rahman & Ramli, 2024). The monitoring process includes providing feedback to help students improve or refine their work. The obstacle at this stage is that some students still do not understand the features of Google Earth, so the teacher's role in this case is to guide students to understand the features of Google Earth.

The final stage in the PjBL steps is assessing the results and evaluating students' experiences during project creation. Furthermore, the teacher and students together evaluate what experiences have been gained during making the project. Students feel very enthusiastic about using Google Earth to learn new things. Using Google Earth as a learning medium, students gain new insights and develop creative thinking skills (Santoso, 2022).

In learning in the experimental class that applied the Project Based Learning (PjBL) model assisted by geospatial technology, several problems arose. First, not all students have adequate access to technological devices such as computers or laptops, and sometimes, unstable internet connections. This may hinder students' engagement in learning. In addition, students may have difficulty understanding how to use the geospatial application Google Earth, which can reduce learning effectiveness and hinder the creative thinking process. Differences in students' initial skill levels can also be problematic, as some students are better prepared than others, so learning outcomes can vary (Mursidik et al., 2015). Finally, the limited time to complete the project may reduce the opportunity for students to think critically and explore their ideas.

On the other hand, the control class that used conventional learning methods also had some problems. This method tends to be less interesting, so students are not motivated to think creatively (Purba & Harahap, 2021). Learning in the control class did not provide enough opportunities for students to work together, which is important for exchanging ideas and developing creativity. In addition, without the use of geospatial technology, students cannot see how the material they learn is applied in real life, thus reducing creative thinking skills. The learning methods used tend to be less interactive and engaging. This means that students receive more information passively, such as through lectures or teaching that does not involve active participation (Depita, 2024). This can make students feel bored and less motivated, affecting their understanding and creative thinking skills. This happens because students in the experimental class are more engaged and have a more interesting learning experience. They tend to get higher scores compared to students in the control class.

From the results of data processing, it was found that the value that had the highest difference in the experimental class and control class was in the elaboration indicator (elaboration) of 14.41. Elaboration refers to the ability of students to develop their ideas in more depth, connect new information with existing knowledge, and expand ideas through research and discussion (Wahyuni et al., 2023). In the project planning PJBL syntax, students are encouraged to formulate a clear work plan, including determining goals, identifying necessary resources, and dividing tasks among groups (Mariya et al., 2024). In this case, the project planning syntax has problems when applying it to learning, especially in the control

https://doi.org/10.51276/edu.v6i2.1271

class. Not all students have sufficient planning skills. They still do not know how to plan the steps needed to achieve project goals, which can cause confusion that interferes with the project completion process.

D. Conclusion

Based on the study results, using the Project Learning (PjBL) model assisted by geospatial technology such as Google Earth improves the creative thinking ability of class X students at SMAN 2 Batu. The PjBL model provides space for students to actively explore, design, and complete contextual projects, thus encouraging the development of creative thinking indicators such as fluency, flexibility, originality, and elaboration optimally.

The results showed that the learning process with the PjBL model obtained a higher post-test score, with an average of 84.84, compared to students who received conventional learning in the control class, which had an average score of 74.00. This finding shows that integrating project-based learning models and geospatial technology can create a more interactive and meaningful learning environment. This is a strategic solution for overcoming the limitations of conventional learning methods that are passive.

Further research is recommended to be conducted at different levels of education, such as elementary school or college level, to determine the consistency of the effectiveness of the Project Based Learning (PjBL) model assisted by geospatial technology in various contexts and ages of students. In addition, the learning materials used also need to be varied to obtain a broader picture of the application of this model in other fields of study, not only in geography subjects. It is also recommended to add other variables, such as learning motivation, critical thinking ability, or student collaboration, to gain a more thorough understanding of the influence of the PjBL model on various aspects of 21st-century skills.

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