

Fostering Creative Thinking Skills on High and Low Cognitive Levels Students with Project-based Inquiry Learning

Vonny^{1*}, Diana Vivanti Sigit², Supriyatin³ 

^{1,2,3}Department of Biology Education Magister Program, Faculty of Mathematics and Sciences, Jakarta State University, Jakarta, Indonesia

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ABSTRAK

Integrasi pengembangan soft skill, seperti berpikir kreatif, ke dalam pembelajaran di kelas merupakan hal yang penting. Penelitian ini bertujuan untuk menganalisis apakah kemampuan berpikir kreatif siswa dapat ditingkatkan melalui pembelajaran inkuiri berbasis proyek yang bervariasi untuk tingkat kognitif tinggi dan rendah. Penelitian ini menggunakan desain kuasi eksperimen dengan faktorial 2x2. Penelitian dilakukan di salah satu SMA swasta, selama lebih dari sebulan. Empat puluh enam siswa kelas sebelas terlibat dalam penelitian ini. Sampel terdiri dari 23 siswa berkemampuan kognitif tinggi dan 23 siswa berkemampuan kognitif rendah, ditentukan dengan menggunakan instrumen kemampuan kognitif. Keterampilan berpikir kreatif diukur dengan membandingkan N-gain skor pretest dan posttest menggunakan instrumen berpikir kreatif. Hasil penelitian menunjukkan bahwa tingkat kognitif berpengaruh signifikan terhadap keterampilan berpikir kreatif, dan terdapat pengaruh interaksi antara variasi model PjBl dengan tingkat kemampuan kognitif. Hasil penelitian mengimplikasikan bahwa siswa dengan tingkat kognitif tinggi memiliki kemampuan berpikir kreatif yang lebih baik ketika belajar dengan PjBl mandiri. Sebaliknya, siswa berkemampuan kognitif rendah menunjukkan kemampuan berpikir kreatif yang lebih baik ketika belajar dengan PjBl terbimbing.

ABSTRACT

Integrating the development of soft skills, such as creative thinking, into classroom learning is essential. This study aims to analyze whether students' creative thinking skills can be enhanced through project-based inquiry learning that is varied for high and low cognitive levels. This research used a quasi-experimental design of 2x2 factorial. The research was done at a private senior high school for over a month. Forty-six eleventh-grade students were involved in this study. The samples consist of 23 high- and 23 low-cognitive ability students, which were determined using a cognitive ability instrument. The creative thinking skill was assessed by comparing the N-gain of the pretest and posttest scores using a creative thinking instrument. The results revealed that the cognitive level affects creative thinking skills significantly, and there is an interaction effect between the variation of the PjBl model and the cognitive ability levels. This result implies that students with high-cognitive levels performed better on creative thinking skills when learning with independent PjBl, while low-cognitive students showed better creative thinking skills when learning with guided PjBl.

1. INTRODUCTION

Creativity is a process that can lead to innovation in various fields. Some life skills, such as the ability to think creatively and innovatively, are expected for the competition for human resource needs in the era of globalization. Everyone is capable of thinking creatively, but this skill needs to be trained and developed (Grigorenko, 2018; Kim, 2019). Development of creative thinking skills involves applying obtained knowledge to new perspectives outside the classroom (Anastasiades, 2012; Rodríguez et al., 2019). Project-based learning (PjBL) and the inquiry model are suitable for enhancing creative thinking skills within classroom activities. Project-based learning is one learning model recommended in Indonesian curricula for developing some important soft skills, such as creative thinking. As stated in the document "Kurikulum Merdeka," developing Pancasila's youth characters, of which one is creativity, should be integrated into school subjects. One example is fostering creative thinking skills through PBL on

*Corresponding author

E-mail addresses: gandawiguna.vonny@gmail.com (Vonny)

environmental changes in a biology lesson (Pamungkas & Sudigdo, 2022; Satria et al., 2022). Improving creative thinking skills could not happen instantly. These skills will be developed in line with the opportunities given to each learning activity (Kim, 2019; Wahyudi & Winanto, 2018). Several studies have proven that project-based learning and inquiry can improve creative thinking skills (Liu et al., 2021; Santi et al., 2018; Yamin et al., 2020). Some research done earlier showed that project-based science learning improves creative thinking skills significantly (Nuswowati & Taufiq, 2015; Ummah et al., 2019; Yamin et al., 2020). Various studies have carried out the PjBL model with various modifications to achieve more specific learning objectives. For example, a study about the effect of the PjBL-STEM model on science process skills, the development of project-based blended learning to increase the creativity of pre-service teachers (Mufida et al., 2020; Wahyudi & Winanto, 2018). PjBL can also collaborate with the inquiry process, so it is referred to as “project-based inquiry learning” (Isabekov & Sadyrova, 2018; Spires et al., 2012, 2019, 2022). Previous study applied PjBL variations (free and guided) to the creative thinking skills of preserving teachers (Fatimah, 2018). The results showed that with free PjBL, the improvement of creative thinking skills was better.

Despite being effective for fostering creative thinking abilities, project-based learning is more challenging to prepare for and implement than traditional learning. According to previous study both the teacher's and the students' abilities to create and complete projects have an impact on PjBL's effectiveness (Cintang et al., 2018). In addition, the development of creative thinking skills is also influenced by cognitive abilities (Frith et al., 2020; Liu et al., 2021). A study in high school students, showed that students with high academic abilities had higher scores in creative thinking skills compared to students with low academic abilities (Santi et al., 2018). The result of this study implies that cognitive ability may affect the development of creative thinking skills. Previous study found a correlation between cognitive capacity and the ability to think creatively (Furnham, 2016). In addition, earlier research found that academic achievement and spatial intelligence, both of which demonstrate conceptual understanding, can enhance students' development of creativity (Suprpto et al., 2018). Some researchers focused on the effect of PjBL on creative thinking skills; however, there have been limited studies concerned with the effect of this learning model on creative thinking skills in students with high and low cognitive levels. Therefore, this research intends to investigate the effect of project-based learning with variation in the cognitive abilities levels on improving students' creative thinking skills. In order to encourage students' creative thinking abilities, this research aims to examine the impact of project-based learning, which is integrated with the inquiry process, on students with high and low cognitive levels. Thus, the learning model is called project-based inquiry (PjBI). Two levels of project-based inquiry learning: independent PjBI and guided PjBI were applied to students with high and low cognitive levels. The objectives of this research are to analyze the effect of PjBI variation on creative thinking skills, the effect of cognitive level on creative thinking skills, and the interaction of PjBI variation and cognitive level on the development of students' creative thinking skills. The uniqueness of this study resides in determining if the two PjBI models and the two levels of cognitive ability interact to influence how students' creative thinking abilities evolve.

2. METHOD

This research used a quasi experimental 2x2 factorial design, as shown in Table 1. Two experimental variables, each with two levels, were applied in this research (Rogers & Revesz, 2019). The PjBI learning model was varied into independent PjBI and guided PjBI. The cognitive abilities were varied into high and low levels. This research was conducted in a private school in Tangerang Selatan for over one month. Forty-six eleventh-grade students were involved in this study. The samples in each cell are as follows: eleventh students with high-cognitive level study with independent PjBI (A₁B₁), twelve students with low-cognitive level study with independent PjBI (A₁B₂), twelve students with high-cognitive level study with guided PjBI (A₂B₁), and eleventh students with low cognitive level study with guided PjBI (A₂B₂). The factorial design is show in Table 1.

Table 1. Factorial design 2x2

Cognitive abilities level (B)	Project Based Inquiry Model (A)	
	Independent (A ₁)	Guided (A ₂)
High (B ₁)	A ₁ B ₁	A ₂ B ₁
Low (B ₂)	A ₁ B ₂	A ₂ B ₂

In this study, in order to develop students' creative thinking abilities, the learning was done in two models: independent PjBI and guided PjBI, for both high- and low-cognitive level students. The syntax of both learning models is similar, but their learning activities differ. The main difference resides in the inquiry process and the teacher's guidance during the learning. Detailed learning activities for independent and guided PjBI are shown in [Table 2](#).

Table 2. Syntax of Project-based Inquiry Learning, Learning Activities of Independent and Guided PjBI

Synthax	Learning activities	
	Independent PjBI	Guided PjBI
Ask a compelling questions	Driving questions were given, students identify the problems independently (free-inquiry).	Driving questions & guided-inquiry questions were given, identify the problem by guidances.
Gather and analyze sources	Create a schedule independently	Create a schedule within deadline that has been determined.
Creatively synthesis, Claims and Evidences	Distribution of tasks. Literature study and field investigation to answer the driving questions independently.	Distribution of tasks. Literature study and field investigation based on guided-inquiry questions .
Critically evaluate & revise	Create products for solution. Students critically evaluate the result and process, teacher monitors and give comments.	Create products for solution under teacher's supervision. Evaluate the result and process, teacher critically evaluate and give suggestions for revision.
Share, Publish, Act	Project action.	Project action.

An instrument to measure creative thinking skills was created and tested for its validity and reliability. This instrument is then used as a pretest and posttest to measure the development of creative thinking skills before and after the PjBI model is applied. Data collection technique was done by calculating the pretest score, posttest score, and N-gain score of the creative thinking instrument. The N-gain equation is stated in the following equation. Statistical tests on the N-gain score of creative thinking skills were carried out using a two-way ANOVA.

3. RESULT AND DISCUSSION

Result

The development of creative thinking skills was measured by comparing the posttest score to the pretest score after the PjBI model was applied. [Table 3](#) shows the measurement of creative thinking skills for each group.

Table 3. Descriptive statistic of Pretest and Posttest Creative Thinking Skills

Indikator	A1B1		A1B2		A2B1		A2B2	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
N	11	11	12	12	12	12	11	11
Mean	62.39	82.64	49.99	63.07	60.98	78.03	49.79	65.39
Min	47.73	71.59	40.91	47.73	51.14	64.77	38.64	52.27
Max	68.18	90.91	56.82	72.73	69.32	87.5	57.95	72.73
St dev	5.87	6.29	4.89	6.86	6.70	7.04	5.49	6.25

[Table 3](#) indicates that there is an increase in the average posttest scores compared to the average of pretest scores for each group. The highest increase in the value of creative thinking skills occurred in group A1B1, which was 20,25 points, while the lowest increase occurred in group A1B2, which was 15,6 points. In addition, the minimum and maximum values of posttest scores were also improved for each group. Graph of pretest and posttest score of creative thinking skills dimensions is show in [Figure 1](#).

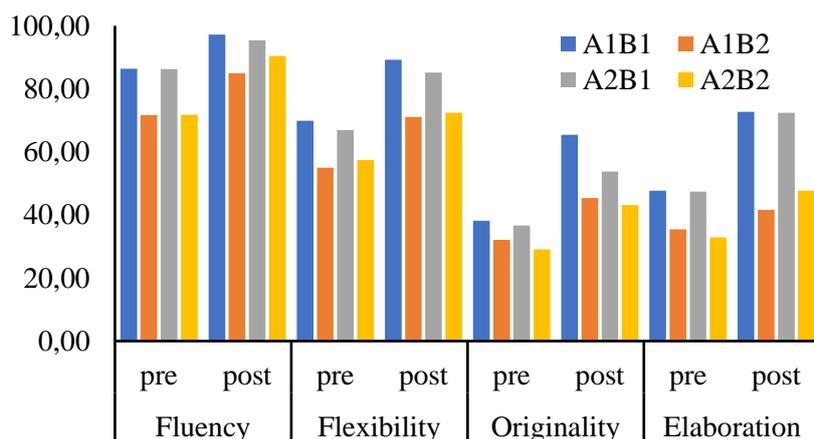


Figure 1. Graph of Pretest and Posttest Score of Creative Thinking Skills Dimensions

Creative thinking skills have four dimensions: fluency, flexibility, originality, and elaboration. Figure 1 shows the pre- and posttest scores based on the creative thinking skills dimensions. Based on the graph, it appears that there is an increase in creative thinking skills in each dimension. The dimensions for which posttest scores were obtained, from highest to lowest were fluency, flexibility, elaboration, and originality. Statistic descriptive of N-gain is show in Table 4.

Table 4. Statistic Descriptive of N-gain

PjBI Variation	Cognitive abilities level	Mean	Stdev	N
Independent	Low	0.26	0.08	12
	High	0.54	0.13	11
	Total	0.39	0.17	23
Guided	Low	0.31	0.07	11
	High	0.44	0.12	12
	Total	0.38	0.12	23
Total	Low	0.29	0.08	23
	High	0.49	0.13	23
	Total	0.39	0.15	46

The N-gain score was calculated to determine the effect of PjBI variations and cognitive ability level on creative thinking skills, as shown in Table 4. The N-gain total scores for independent and supervised PjBI were, respectively, 0.39 and 0.38. Unlike the total score of cognitive abilities level, both of these scores do not show a big difference. The N-gain total score for the high cognitive level was 0.49, higher than the low cognitive group, which was 0.39. Result of statistical tests is show in Table 5.

Table 5. Result of Statistical Tests (Two-Way ANOVA) of N-gain Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	0.545 ^a	3	0.18	17.17	<.001
Intercept	7.06	1	7.06	668.41	<.001
Variasi_PjBI	0.00	1	0.00	0.77	0.38
Tingkat_Kognitif	0.47	1	0.48	45.28	<0.001*
Variasi_PjBI *	0.06	1	0.06	5.89	0.02*
Tingkat_Kognitif					
Error	0.44	42	0.01		
Total	8.00	46			
Corrected Total	0.98	45			

Statistical tests with a two way ANOVA as show in Table 5 show that for the effect of PjBI variations, the p-value is greater than alpha (0.38 > 0.05). Thus, it can be concluded that the variation of PjBI does not significantly influence creative thinking skills. Meanwhile, for variations in cognitive level, the p-value is lower than alpha (0.001 < 0.05). Thus, it can be concluded that cognitive ability has a

significant effect on creative thinking skills. The interaction effect between pjbi variations and cognitive levels is show in [Figure 2](#).

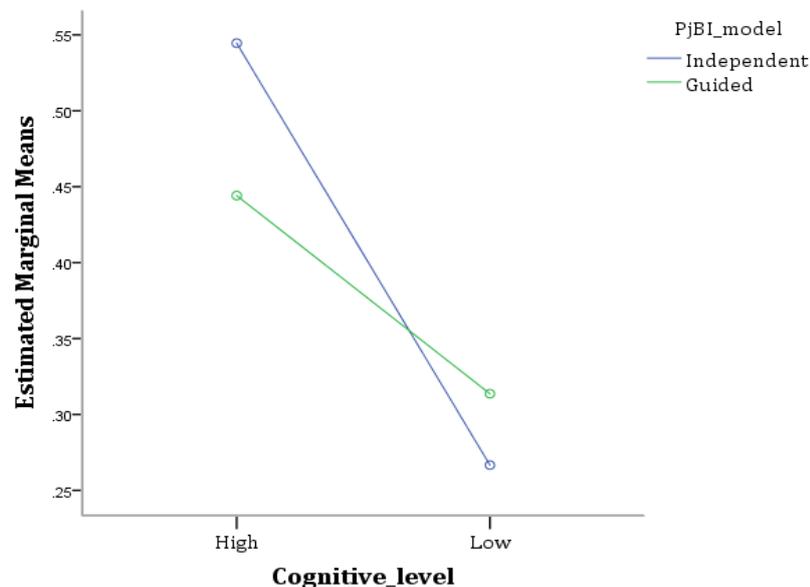


Figure 2. The Interaction Effect between PjBI Variations and Cognitive Levels

The p-value for the interaction effect between PjBI variation and cognitive abilities level is lower than the alpha value ($0.02 < 0.05$). Therefore, it can be concluded that there is a significant interaction effect between variations in the PjBI model and variations in the level of cognitive ability on creative thinking skills. Two intersecting lines, as shown in [Figure 2](#) indicate the interaction effect between the PjBI variations and cognitive ability level. Low cognitive ability students obtained a higher average N-gain score when learning with the guided PjBI model (0.31), compared to the independent PjBI model (0.26). Conversely, for high cognitive ability students, the average N-gain score is higher when learning with the independent PjBI model (0.54) compared to the guided PjBI model (0.44).

Discussion

In this study, the effects of the variation of project-based inquiry learning (PjBI) and the cognitive levels toward the development of creative thinking skills were examined. The study's findings indicated that creative thinking abilities are influenced by cognitive ability. However, both high and low cognitive groups can benefit from proper flexibility in instruction during the learning process, which will enhance their capacity for creative thought ([Ghaedi et al., 2014](#); [Hawari & Noor, 2020](#)). Thus, the research's goals have been met. The PjBI model's syntax has to be modified and customized to meet the demands of students while they are studying in order to enhance students' creative thinking abilities at all cognitive levels. This study offers a fresh perspective on the need for teachers to be more adaptable and sensitive to students' needs and cognitive skills throughout the learning process.

The creative thinking skills posttest for each group increased compared to the pretest after learning with the PjBI model. The PjBI model requires students to express their thoughts, build new meanings and knowledge, and eventually find solutions to real problems given through driving questions. This shows that learning with the PjBI model has stimulated creative processes, both in the high-cognitive and low-cognitive groups. Based on theory, the development of creative thinking skills can be done through actions and behaviors that appear in class activities, especially those that involve solving problems ([Al-Ababneh, 2020](#); [Rudyanto, 2016](#)). The current findings are similar to earlier research designed specifically for preservice teachers that showed that project-based learning can stimulate students to develop creative thinking skills ([Fatimah, 2018](#); [Suryandari et al., 2018](#)). In this study, students' creative thinking skills increased in all dimensions. Working on project-based inquiry learning, students are involved in constructing knowledge by working on projects related to real problems and offering appropriate solutions or products ([Guo et al., 2020](#); [Miller & Krajcik, 2019](#)). Thus, students are required to carry out creative thinking processes while studying with PjBI. In the initial stages of PjBI, students are trained to identify various existing problems (fluency), and with various points of view

(flexibility). In the final stage, students are required to create relevant new solutions (fluency, flexibility, & originality). In addition, students may also make improvements to the solutions/products that have been created (elaboration). The activities used in the present study emphasized inquiry, exploration, and problem-solving using the obtained knowledge, which encouraged students to produce original products and actions to solve the real-world problem of climate change. Some learning stages of the PjBI encourage students to think creatively, in both independent and guided PjBI. Variation in the inquiry process mainly affects the inquiry and exploration stages, which involve cognitive processes. Therefore, the PjBI model variation did not affect creative thinking skills significantly. But the interaction of the PjBI model with the levels of cognitive ability affects creative thinking skills significantly.

According to Bloom's taxonomy theory, cognitive abilities are related to recognition, and the process of recalling knowledge, as well as the development of intellectual abilities and skills. The highest level of high cognitive ability is the ability to create something (Anderson et al., 2001; Bloom et al., 1956). Based on this theory, it can be explained that the ability to create something is the highest stage of cognitive ability. In addition, according to the theory of fluid intelligence, when learning new things, students' fluid intelligence determines the speed and depth of their understanding (Kyllonen & Kell, 2017; Lestari et al., 2022). Learning with the PjBI model requires students to answer questions, seek information, and analyze the relationship between observed phenomena and the information obtained. Then students take action to answer the problem given. Cognitive abilities are required at the stages of literature study and field investigation.

The present findings show that the enhancement of creative thinking skills for high-cognitive level students is better when learning with the independent PjBI than the guided PjBI. At the final stage of the PjBI model, students are required to create products and actions as the solution to a given problem. Before creating the solutions, students should have understood the problems, conducted a literature study to find new knowledge, and analyzed some information. Therefore, they understood the relationship between observed phenomena and were eventually able to propose relevant and appropriate solutions. This is consistent with Bloom and Anderson's theory, according to which the ability to create something is the highest cognitive level in the Taxonomy Bloom domain on cognition (Anderson et al., 2001; Bloom et al., 1956). A study of brain activity also supports this finding. It stated that creative thinking and intelligence rely on the same neural and cognitive systems (Frith et al., 2020). As a consequence, high-cognitive level students have a more solid foundation for developing solutions. Therefore, they were able to perform creative thinking skills with minimal guidance. Students with a low cognitive level, on the other hand, performed better in creative thinking skills when learning with the guided PjBI. Teacher guidance during the inquiry and exploration process assists students to have a better understanding of the phenomena before creating the solutions. Some researchers have studied the effect of project-based learning on developing creative thinking skills, but limited studies have related it to the levels of cognitive ability. The novelty finding of this research is that there is an interaction effect between the PjBI model and cognitive ability levels. Students with high cognitive levels were more suitable for independent PjBI. Whereas for students with low cognitive abilities, the teacher's guidance is needed, so it is more appropriate to learn with guided PjBI.

4. CONCLUSION

Based on the research findings in this study, it can be concluded that the variation of the project-based inquiry model into two levels showed no significant effect on creative thinking skills, but cognitive ability levels did influence creative thinking skills significantly. Evidently, there is a significant interaction effect between the variations in PjBI learning models and the level of cognitive abilities on creative thinking skills. Thus, the result of this study implies that independent PjBI is more suitable for students with high cognitive abilities, while guided PjBI is more suitable for students with low cognitive abilities. The results of this study are expected to have implications for teachers, who should pay attention to the students' cognitive ability when developing their creative thinking skills through project-based learning. Subsequent research to find out the effect of learning motivation and the creative process that occurs during project-based inquiry learning is suggested for further study.

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