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Correlation of cognitive learning outcomes and creativity in PjBL with culturally responsive teaching

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ABSTRACT

Learning in the 21st century emphasizes higher-order thinking skills, particularly creativity and cognitive ability. However, observations in biology learning indicate that students' creative thinking and conceptual understanding remain low, especially in biotechnology material. This study aims to determine the correlation between cognitive learning outcomes and creativity through the implementation of the Project-Based Learning (PjBL) model with the Culturally Responsive Teaching (CRT) approach. The research employed a quantitative correlational design involving 72 students of Grade X at SMA Negeri I Depok, Sleman, Yogyakarta. Data on creativity were collected using a validated creativity rubric, while cognitive learning outcomes were obtained from post-test scores. Data were analyzed using the Pearson product-moment correlation test with SPSS. The results showed that there was no significant correlation between cognitive learning outcomes and creativity ($r = 0.090$; $p = 0.455 > 0.05$). This finding suggests that an increase in cognitive learning outcomes does not necessarily lead to an increase in creativity. Thus, although the implementation of the PjBL-CRT approach contributed positively to students' learning experiences, cognitive and creative abilities tended to develop independently. These results suggest the need for further learning strategies that explicitly integrate creative processes into cognitive learning tasks in biotechnology education.

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INTRODUCTION

Twenty-first-century learning emphasizes higher-order thinking skills such as creativity, critical thinking, collaboration, and problem solving (Partnership for 21st Century Skills, 2019).

Among these skills, creative thinking has become one of the essential competencies to be developed. The 2022 PISA results revealed that only about 5% of Indonesian students achieved a proficient level in creative thinking, indicating that students' creativity remains relatively low. In addition to critical and creative thinking skills, cognitive knowledge mastery is also important to support meaningful learning outcomes. Cognitive learning outcomes refer to the revised Bloom's taxonomy by Anderson & Krathwohl (2001), which combines two dimensions: the knowledge dimension (factual, conceptual, procedural, and metacognitive) and the cognitive process dimension (remembering, understanding, applying, analyzing, evaluating, and creating).

Creativity is one of the internal factors influencing students cognitive learning outcomes. Students with higher creativity tend to generate innovative ideas and achieve a deeper understanding of concepts. In biology learning, particularly in biotechnology, the issue of low creativity and conceptual understanding remains evident. Nugraini & Amelia (2023) reported that many students struggle to explain the scientific processes involved in biotechnology and tend to memorize information without fully understanding the concepts.

Creativity is the ability of individuals to produce something new, either in the form of original ideas or innovative products (Munandar, 2009). In the context of learning, creativity is an essential aspect that encourages students to think openly and explore various alternative solutions to problems. Susanto (2011) stated that creativity can be viewed through four indicators: fluency, flexibility, originality, and elaboration. These four aspects reflect students' abilities to generate many ideas, propose diverse solutions, think uniquely, and develop ideas in greater detail. Thus, creativity does not only represent the ability to think originally but also the skill to process ideas into something meaningful and useful.

The Project-Based Learning (PjBL) model has great potential to enhance students' creativity by involving them in designing real-world projects (Patmawati et al., 2023). This model also aligns with the Merdeka Curriculum, which emphasizes contextual and project-based learning experiences (Forniawan, 2022). However, the lack of laboratory facilities and monotonous teaching methods often reduces students' engagement and creativity (Gaghunting & Bermuli, 2023). Therefore, an instructional model that fosters both cognitive learning outcomes and creativity is needed.

Integrating the Culturally Responsive Teaching (CRT) approach into the PjBL model enables students to connect scientific concepts with their local cultural contexts(Gay, 2018). This approach is also in line with the Merdeka Curriculum's emphasis on incorporating local cultural values into classroom instruction. In the Yogyakarta region, one of the local biotechnology-based potentials is growol, a traditional fermented food from Kulon Progo made from naturally fermented cassava. Growol has functional food potential due to its content of lactic acid bacteria, which provide health benefits (Lukisworo, 2021). However, growol is traditionally produced using simple fermentation and processing methods, which cause it to have a relatively short shelf life. According to Wicaksono et al (2022), the soaking and cleaning stages during the production process determine the quality of growol. When these processes are not carried out hygienically, growol often produces an unpleasant odor. This odor issue has become one of the main obstacles preventing wider public acceptance of growol as a daily food. Therefore, students are encouraged to innovate by improving the quality, hygiene, and presentation of growol through project-based biotechnology learning. Such innovation activities can enhance their creativity while deepening their understanding of the fermentation process and its application in real-life contexts.

This study focuses on cognitive learning outcomes and students' creativity in the Biotechnology topic for Grade XI (Phase E). Based on previous studies, there has been no research specifically investigating the correlation between cognitive learning outcomes and creativity through the Project-Based Learning (PjBL) model with a Culturally Responsive Teaching (CRT) approach in the context of local biotechnology, such as growol. Therefore, this study aims to determine the correlation between cognitive learning outcomes and creativity through the implementation of the PjBL model with a CRT approach in biotechnology learning.

RESEARCH METHODS

Research Design

The method used in this study was a quantitative approach with a correlational design, aimed at determining the relationship between students' creativity and cognitive learning outcomes through the implementation of the Project-Based Learning (PjBL) model integrated with the Culturally Responsive Teaching (CRT) approach. This design was selected to identify the extent to which variations in students' creativity are associated with their cognitive learning achievements after participating in learning activities that emphasize project development, cultural relevance, and contextual problem-solving. The quantitative approach enables the use of numerical data and statistical analysis to objectively describe and interpret the correlation between variables, providing empirical evidence on how the integration of PjBL and CRT supports both creative thinking and academic performance in biotechnology learning.

Population and Samples

The population of this study consisted of students in Grade X at SMA Negeri 1 Depok, Yogyakarta. The sample used in this study was 36 students, with a random sampling technique.

Instruments

This study utilized two main instruments: a cognitive learning achievement test and a creativity observation sheet. The cognitive learning test was used to assess students' cognitive learning outcomes. The test consisted of five essay questions developed based on the Revised Bloom's Taxonomy. The test items focused on cognitive levels C3 to C5 (applying, analyzing, and evaluating) because these levels align with the learning objectives of biotechnology material that emphasize higher-order thinking skills. Lower levels (C1–C2) were excluded as they mainly assess recall and basic understanding, which were already assumed to be mastered by students before the intervention. Meanwhile, C6 (creating) was not included because students' creativity was measured separately through the creativity observation sheet rather than cognitive test items. Students' answers were scored using an assessment rubric to measure the depth of conceptual understanding and reasoning accuracy. The blueprint for assessing students' cognitive learning outcomes is presented in Table 1.

Table 1. Cognitive Learning Outcome Grid

Indicator	Posttest
Constructing simple procedures related to biotechnology experiments	C3
Analyzing the advantages and disadvantages of certain biotechnology methods	C4
Identifying the relationship between biotechnology concepts and real-life cases in society	
Assessing the impact of biotechnology on the environment and human health	C5
Considering ethical aspects in the use of biotechnology for specific purposes	

The creativity observation sheet was designed to measure students overall creativity during the project implementation. It consisted of four key dimensions of creativity: fluency, flexibility, originality, and elaboration. Fluency refers to the ability to generate multiple ideas, flexibility represents the ability to think from various perspectives, originality reflects the ability to produce unique and innovative ideas, and elaboration indicates the ability to develop and refine ideas in detail. The observation sheet contained nine items used to evaluate students creative performance throughout the learning proces (Sulastri et al., 2022). The blueprint for assessing students' creativity is presented in Table 2.

Table 2. Creativity student Grid

Dimension	Indicator
Fluency	Smooth flow of thought
	Able to provide a variety of answers
Flexibility	Generates varied ideas
	Different ways of thinking
	Able to mention various alternative answers
Originality	Able to provide answers that are different from the general way of thinking
	Able to provide new model/design creations
Elaboration	Able to explain something in detail
	The answers provided are clear and detailed

Both instruments underwent expert validation to ensure content accuracy and suitability. The cognitive learning test was validated by material and education experts, followed by validity and reliability testing to confirm the quality of the instrument. Meanwhile, the creativity observation sheet was validated by experts to ensure its appropriateness for measuring students' creative performance during the learning process.

Procedures

This study was conducted at SMA Negeri I Godean during the 2025 academic year on the topic of Biotechnology, focusing on local fermented food products such as Growol. The research procedure consisted of three main stages: learning implementation, data collection, and data analysis.

During the implementation stage, students engaged in learning activities based on the Project-Based Learning (PjBL) model integrated with the Culturally Responsive Teaching (CRT) approach. In these activities, students collaboratively designed innovative biotechnology products using local ingredients. The learning is designed to enhance students' scientific understanding, creativity, and cultural awareness through contextual and project-based experiences.

Students' creativity was assessed using a creativity observation sheet consisting of nine indicators representing fluency, flexibility, originality, and elaboration. The observation was conducted by three trained observers to ensure objectivity and inter-rater reliability in the data collection process. Meanwhile, students' cognitive learning outcomes were measured using a written cognitive test focusing on the levels of applying (C3), analyzing (C4), and evaluating (C5) according to Bloom's taxonomy.

After all data were collected, analysis was performed using SPSS version 30. A Pearson Product-Moment correlation test was applied to determine the relationship between students' creativity and their cognitive learning outcomes following the implementation of the PjBL–CRT learning model.

Data Analysis

To determine the validity level of the developed media and categorize students' creativity levels, descriptive data were analyzed based on percentage scores and converted into qualitative categories. The criteria for each aspect are presented in the following tables. The results of the E-LKPD validation by media experts were analyzed using percentage scores and interpreted based on the criteria in Table 3.

Table 3. Categories of Student Cognitive Learning Outcomes

Mastery Level	Standard Score
90% - 100%	Very Good
80% - 89%	Good
70% - 79%	Fair
60% - 69%	Poor
>59%	Very Poor

(Afandi, 2013)

Meanwhile, the students' creativity levels were categorized based on the percentage results obtained from the observation sheet. The criteria used to interpret the level of creativity are shown in Table 4.

Table 4. Creativity Level Criteria

Mastery Level	Standard Score
86%-100%	Very Creative
76% - 85%	Creative
60%-75%	Moderately creative
55% - 59%	Less Creative
>54%	Not Creative

(Budi & Izzati, 2021)

The data analysis in this study used SPSS version 30. The analysis consisted of three stages: the normality test, the linearity test, and the hypothesis test. The normality test was conducted using the Shapiro–Wilk test to determine whether the data were normally distributed. The data were considered normally distributed if the significance value was greater than 0.05 (Ghozali, 2018). The linearity test aimed to determine whether there was a linear relationship between the variables, with the data being considered linear if the significance value of the deviation from linearity was greater than 0.05 (Sugiyono, 2019). The final stage was the hypothesis test, conducted using the Pearson Product-Moment correlation analysis, to examine the relationship between creativity and cognitive learning outcomes of students through the Project-Based Learning (PjBL) model with a Culturally Responsive Teaching (CRT) approach. The variables were considered to have a significant relationship if the significance value was less than 0.05 (Dawolo et al., 2025).

RESULTS

Data from this study included students' creativity observations and cognitive learning test results. Cognitive learning outcomes were measured based on the Revised Bloom's Taxonomy at levels C3 (applying), C4 (analyzing), and C5 (evaluating) (Anderson & Krathwohl, 2010). The data were analyzed using normality, linearity, and Pearson product-moment correlation tests with SPSS version 30 to determine the relationship between creativity and cognitive learning outcomes in biotechnology learning through the Project-Based Learning (PjBL) model with a Culturally Responsive Teaching (CRT) approach. Figure 1 presents the average percentage for each cognitive learning, and Table 1 presents the Creativity Percentage Score.

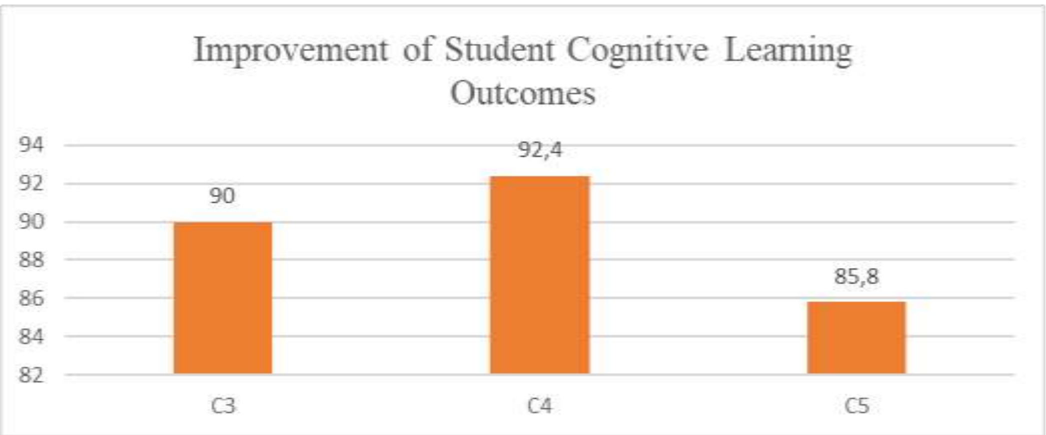

Figure 1. Diagram of students learning outcomes

Table 6. Creativity Percentage Score

Indicator	Percentage	Category
C3	90%	Verry Good
C4	92,4%	Verry Good
C5	85,8%	Good

Figure 1 illustrates the improvement in students' cognitive learning outcomes at levels C3, C4, and C5 after participating in learning activities through the Project-Based Learning (PjBL) model integrated with the Culturally Responsive Teaching (CRT) approach. The highest improvement was observed at the C4 (analyzing) level, which reached 92.4%, indicating that students became more capable of analyzing and interpreting biotechnology concepts in depth. Meanwhile, the C3 (applying) and C5 (evaluating) levels also showed high posttest scores of 90% and 85.8%, respectively, categorized as "very good" and "good." These findings suggest that the integrated PjBL–CRT learning model effectively enhanced students' higher-order thinking skills, particularly in applying, analyzing, and evaluating biotechnology concepts. Students' creative performance is presented in Table 6.

Table 5. Creativity Percentage Score

Dimension	Indicator	Result	Category
Fluency	Smooth flow of thought	90,3 %	Very Creative
	Able to provide a variety of answers	80,6 %	Creative
Flexibility	Generates varied ideas	80,6 %	Creative
	Different ways of thinking	70,3 %	Creative
	Able to mention various alternative answers	70,4 %	Creative
Originality	Able to provide answers that are different from the general way of thinking	70,9 %	Creative
	Able to provide new model/design creations	80 %	Creative
Elaboration	Able to explain something in detail	80,6 %	Creative
	The answers provided are clear and detailed	80,6 %	Creative

Table 6 presents the percentage scores of students' creativity based on four dimensions: fluency, flexibility, originality, and elaboration. The results indicate that students demonstrated a "very creative" level in the indicator smooth flow of thought (90.3%), while most other indicators were categorized as "creative." This shows that students were able to generate various ideas, provide alternative solutions, and express their thoughts clearly during the project activities. The lowest score appeared in the flexibility dimension, specifically in the indicator different ways of thinking (70.3%), which still falls under the "creative" category. Overall, these results suggest that the Project-Based Learning (PjBL) model with a Culturally Responsive Teaching (CRT) approach effectively fostered students' creativity, particularly in generating diverse and original ideas relevant to biotechnology projects. Furthermore, the data obtained were then tested for normality, as presented in Table 6.

Table 6. Shapiro–Wilk Normality Test Results

Variable	Statistic	df	Sig.
Cognitive Learning Outcomes	.948	36	.088
Student Creativity	.964	36	.292

Table 7 shows the results of the Shapiro–Wilk normality test for both variables. The results indicate that cognitive learning outcomes and creativity scores are normally distributed, with significance values greater than 0.05. Specifically, the significance value for cognitive learning outcomes is 0.088, and for creativity is 0.292. These results confirm that the data meet the assumption of normality, allowing the use of parametric statistical analyses. Furthermore, the results of the linearity test of the cognitive learning outcomes and student creativity can be seen in Table 7.

Table 7. Data Linearity Test

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Cognitif Learning Outcomes * Student Creativity	Between Groups	(Combined)	1063.056	9	118.117	1.262	.303
		Linearity	466.256	1	466.256	4.980	.034
		Deviation from Linearity	596.799	8	74.600	.797	.611
	Within Groups		2434.167	26	93.622		
	Total		3497.222	35			

The results of the linearity test between students' cognitive learning outcomes and creativity are presented in Table 8. The results show a significance value of 0.034 for the linearity test and 0.611 for the deviation from linearity. This indicates that the relationship between the two variables is linear (Sig. < 0.05) and does not deviate from the assumption of linearity (Sig. > 0.05). Therefore, the data meet the requirements for further analysis using Pearson's product-moment correlation test.

Table 8. Pearson Product-Moment Correlation Test

Correlations

		Cognitif Learning Outcomes	Creativity
Cognitif Learning Outcomes	Pearson Correlation	1	.090
	Sig. (2-tailed)		.455
	N	72	72
Creativity	Pearson Correlation	.090	1
	Sig. (2-tailed)	.455	
	N	72	72

The results of the Pearson product–moment correlation test between cognitive learning outcomes and creativity are shown in Table 9. The analysis yielded a correlation coefficient (r) of 0.090 with a significance value of 0.455 (> 0.05), indicating a very weak and non-significant positive correlation. This suggests that there is no statistically significant relationship between students' cognitive learning outcomes and their creativity after the implementation of the Project-Based Learning (PjBL) model with a Culturally Responsive Teaching (CRT) approach.

DISCUSSION

The results of this study showed a very weak and non-significant positive correlation (r = 0.090, p = 0.455) between students' creativity and cognitive learning outcomes after implementing the Project-Based Learning (PjBL) model with a Culturally Responsive Teaching (CRT) approach. This finding indicates that although both variables increased after the intervention, the improvement in creativity did not directly correspond to higher cognitive achievement scores.

These results differ from several previous studies that found a positive and significant relationship between creativity and learning achievement. For example, Patmawati et al., (2023) reported that students with higher creative thinking skills tend to achieve better cognitive performance because creativity facilitates the generation of alternative solutions and deeper understanding. Similarly, Fajri et al., (2023) found that PjBL enhances both creative and cognitive skills since project activities stimulate analytical and evaluative thinking.

However, the absence of a significant correlation in this study may be explained by several contextual factors. First, creativity and cognitive learning outcomes are influenced by different types of learning tasks. The creativity indicators in this study (fluency, flexibility, originality, and elaboration) focused on students' ability to design and express ideas during project creation, while cognitive outcomes were measured through written tests at the levels of applying (C3), analyzing (C4), and evaluating (C5). This difference in assessment format may lead to weak correlation, as creative performance in practice does not always align with written cognitive responses (Sukmaangara & Madawistama, 2021).

Second, according to Anderson & Krathwohl, (2001) higher-order cognitive processes such as analysis and evaluation require logical reasoning and conceptual accuracy, whereas creativity emphasizes divergent thinking and innovation. While both are higher-order skills, they develop through different learning pathways. As suggested by Amabile (2018), creativity often thrives in open-ended, exploratory tasks, whereas cognitive achievement depends on structured problem-solving and conceptual mastery.

Another possible explanation relates to the implementation stage of the project. In this study, students may have focused more on completing creative tasks (e.g., designing biotechnological products) than optimizing their understanding of theoretical concepts. Similar findings were reported by Ramadan et al., (2025), who observed that students' creative performance during PjBL was not always followed by improvement in test-based cognitive results, especially when project activities emphasized product creation over reflection and analysis.

Nevertheless, both creativity and cognitive learning outcomes showed high mean scores and improvements, confirming that the integration of PjBL with CRT was effective in engaging students in meaningful learning. The CRT approach encouraged students to connect biotechnology concepts with local culture and everyday life, which aligns with Gay (2018), emphasizing that culturally responsive pedagogy promotes student engagement and self-expression. In summary, although this study did not find a significant statistical correlation between creativity and cognitive learning outcomes, the descriptive improvements indicate that both constructs can develop simultaneously through PjBL-CRT implementation, albeit through different cognitive and affective mechanisms.

CONCLUSION

This study found a very weak and non-significant positive correlation (r = 0.090, p = 0.455) between students' creativity and cognitive learning outcomes after the implementation of the Project-Based Learning (PjBL) model with a Culturally Responsive Teaching (CRT) approach. Although both variables showed improvement, the increase in creativity did not directly correspond to higher cognitive achievement scores. These results indicate that while the PjBL-CRT model effectively enhanced students' engagement, creative expression, and understanding of biotechnology concepts, creativity and cognitive learning outcomes may develop through different cognitive processes. Overall, the PjBL-CRT approach successfully fostered meaningful learning experiences, and future studies are encouraged to employ integrated assessments that can better capture the interplay between creative and cognitive skill development.

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