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Analysis of Students' Creative Thinking Skills and Learning Activities in Physics Learning Using the Project-Based Learning Model

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Abstract: Physics learning often faces challenges in improving students' creative thinking skills and learning activities, which tend to remain low. This presents a significant challenge for educators to identify effective learning models that foster both creativity and student engagement. This study aims to analyze students' creative thinking skills and learning activities in physics learning using the Project-Based Learning (PjBL) model. The research subjects were 29 students of Class A at SMA A in Central Maluku Regency. The research employed a mixed-method approach with a one-group pretest–posttest design. Instruments included a test to measure creative thinking skills and observation sheets as non-test instruments to assess students' learning activities throughout the learning process. Data were analyzed using descriptive quantitative methods in the form of percentages, and qualitative analysis in narrative explanation, supported by a t-test to determine significant differences between pretest and posttest results. The findings showed that 52.5% of students reached a fairly high level of creativity after implementing the PjBL model, with a significant increase in creativity test scores compared to before the intervention. Additionally, observations of learning activities indicated very high student engagement, particularly during presentations, with a percentage reaching 83.25%. These findings demonstrate that the Project-Based Learning model is effective in enhancing students' creative thinking skills while also stimulating active participation in physics learning.

Keywords: Creative Thinking Skills; Student Learning Activities; Project-Based Learning Model

Introduction

Concerns about the learning process in physics are fundamentally based on the observed discrepancy between what teachers teach and what students actually learn (Guisasola et al., 2002). Undoubtedly, learning physics is a challenging task for many high school students. Some argue that physics is often associated with complex calculations and decontextualized models of the world, leaving little room to integrate physics education with children's everyday lives (Areljung et al., 2023). The literature on physics education is filled with examples of students' learning difficulties and alternative conceptions (Thomas, 2013). In many countries, students' interest in physics and science-related careers has not increased. Moreover, the assumption that female students are less interested in science learning, particularly physics, is typically based on surveys rather than measurements in real-life situations. Thus, real-situation measurements can provide insights into how students' situational interests vary during physics lessons. For instance, in Chile, the focus of the module is on integrated physics and biology, whereas in Finland it is on project-based learning in physics (Lavonen et al., 2021). It has been well documented that colleges and universities in the U.S. are not meeting their goals regarding physics education. We are not preparing enough students to become physics teachers (Goertzen et al., 2013).

In physics lessons, students are expected not only to acquire foundational knowledge necessary for further studies in various school disciplines but also to enhance their knowledge, insight, and self-confidence. However, most physics teachers report that around 60% of

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students are unable to independently propose and justify hypotheses, develop activity plans, consider objectives, research and analyze necessary information, conduct experiments, compare available data, and properly reflect and report their findings (Zhanatbekova et al., 2024).

Every mentally healthy individual inherently possesses the potential to develop creative thinking skills (Krauss, 2024). Creative thinking ability is one of the goals that must be achieved in school physics education (Batlolona, 2019). Creativity is essential for survival in an ever-changing modern world (De Alencar et al., 2017). Creativity is the seed of innovation, which is vital for the advancement of human society; hence, a creative workforce is crucial. Creativity drives economic and technological development, is essential for developing new ideas, improving efficiency, and designing solutions to complex problems (Karunarathne & Calma, 2024). A person is considered creative if they can view and connect things from a new perspective, enabling them to solve life problems in fresh, unique, and innovative ways (Widiana et al., 2023). Thus, it can be concluded that creative thinking is a mental activity where a person possesses thinking skills to discover and connect new things, thereby generating new ideas (Ceylan, 2020). The development of creative thinking, which begins in infancy, is shaped by children's early experiences. Just like creative thinking skills, scientific process skills also begin in infancy (Yildiz & Guler Yildiz, 2021). They also indicate that creativity can be developed through teaching, while highlighting that enjoyment, freedom and structure, group interaction, and problem-solving activities are beneficial to the development of creative thinking skills (Tam, 2023).

The word creativity originates from the Latin term creō, which means to create or to make, and it generally refers to the ability to generate original and useful ideas or solutions to problems (Amabile, 1983; Mumford, 2003). Thus, creative thinking skills are inherently linked to normative cognitive functions rather than being innate talents possessed only by a few geniuses (Ritter & Mostert, 2017). Several efforts can be made to enhance students' creative thinking skills, such as providing students with time to think, allowing them solitude for deeper reflection, and facilitating environments and tools that support and stimulate creative thinking (Lai Keun & Hunt, 2006). A healthy parent-child relationship that is not overly possessive, democratic parenting, access to knowledge, a conducive classroom environment, well-prepared educators, the freedom for students to express creativity, and the use of student-centered teaching models all contribute to the development of creative thinking.

In reality, teachers rarely assess the extent of students' creative thinking abilities, as they typically focus on measuring learning outcomes. This is partly due to teachers' difficulties in designing creative-thinking-based questions, which results in monotonous learning that affects students' creativity and does not stimulate curiosity in physics learning. Traditional one-way teaching models often fail to encourage active student participation, making students more passive during lessons (Bavishi et al., 2022). Low creativity can limit students' ability to generate new and innovative ideas for problem-solving (Batlolona, 2023). Creative thinking can be nurtured through practice and habituation in exploration, inquiry, discovery, and problem-solving activities. Although practice can strengthen creative thinking skills, classroom instruction still tends to emphasize rote memorization rather than exercises that foster creativity (Wenno, 2021).

Teachers must be able to engage students by facilitating learning through the selection of appropriate models that activate students, making learning meaningful—in the sense that students find it enjoyable and are empowered to solve problems, thereby naturally stimulating creative thinking. Students who actively interact with peers, ask questions, and participate in discussions have a greater chance of mastering the subject matter (Munna & Kalam, 2021). In line with this, some argue that many students still demonstrate a lack of engagement in learning activities, which may result in poor understanding of the material (Jamaludin & Batlolona, 2021). Learning activity refers to any effort made by students to develop themselves during the learning process (Chukwunemerem, 2023). With the right approach, students' activities can trigger creative thinking skills. To promote creative thinking through meaningful learning activities, a learning model that activates students is necessary (Leasa et al., 2023). One such model that effectively engages students in the learning process is the Project-Based Learning (PjBL) model.

Although PjBL has been widely recognized for its potential to engage students in meaningful learning experiences, most existing research focuses on its implementation in secondary and higher education. In contrast, its application in primary education remains underutilized, and its integration with technology is largely unexplored. Previous studies have highlighted PjBL's effectiveness in fostering students' creativity and problem-solving abilities, but few have examined how these benefits are realized (Marini et al., 2025). Through project-based learning activities, students can develop creative thinking skills that improve their understanding of subject matter and increase learning engagement. PjBL is a learning process designed to encourage students to actively collaborate in solving real-world problems, allowing them to reconstruct their learning based on the projects they undertake (Genc,

2015). PjBL aims to focus students on complex problems that require investigation and promote learning through inquiry (Li et al., 2015). Additionally, PjBL provides a more interactive and contextual learning experience. Learning improvement occurs because students are presented with challenges, thus requiring not only the memorization of concepts but also their application in projects that demand analysis, evaluation, and innovation (Maros et al., 2023). Therefore, this study aims to analyze students' creative thinking skills and learning activities in physics learning using the PjBL model.

Method

The type of research used in this study is descriptive research with a one-group pretest–posttest design, involving a learning treatment using the Project-Based Learning (PjBL) model. The research design diagram is as follows:

$$U_1 \longrightarrow L \longrightarrow U_2$$

Description

U1 : Pretest to assess the initial ability of creative thinking on the topic of linear motion

U2 : Posttest to assess the final ability of creative thinking on the topic of linear motion

X : Treatment using the project-based learning model

The population of grade X students at SMA A in Central Maluku Regency consists of 57 students, with a research sample of 29 students from class A. The research instruments used were: 1) Test instrument, which consisted of 16 essay questions covering four aspects of creative thinking skills, namely: a) Fluency, b) Flexibility, c) Originality and d) Elaboration. 2) Non-test instrument, in the form of a student learning activity observation sheet. The observed indicators of student learning activities during the lesson included: a) Engagement in discussions, b) Participation in practical activities, c) Discipline in learning and d) Responsibility.

Data analysis in this study was carried out using quantitative descriptive analysis to describe the data as-is in the form of percentages, and explain the data or occurrences using qualitative explanatory statements. The data analysis techniques used included: qualitative descriptive analysis, which analyzed students' creative thinking skills and learning activities using the PjBL model. The research results were analyzed using t-test statistics.

Results and Discussion

Based on the results of the pretest, it was found that all students did not pass or did not meet the criteria for any of the creative thinking skill indicators, as creative thinking was a new concept for them. Meanwhile, the posttest results showed the achievement of various percentages for each creative thinking skill indicator, as presented in Table 1.

Table 1. Creative Thinking Skills Data

Creative Thinking Skills Indicators	Pretest average score (%)	Posttest average score (%)	Achievement (%)
Fluency	25	75	50
Flexibility	22	74	52
Originality	15	65	50
Elaboration	5	63	58
Average	16.75	69.25	52.5

Table 1 shows that among the four indicators of students' creative thinking skills, the Elaboration indicator had the highest level of achievement, while the indicators with the lowest scores were Fluency and Originality, as illustrated in Figure 1.

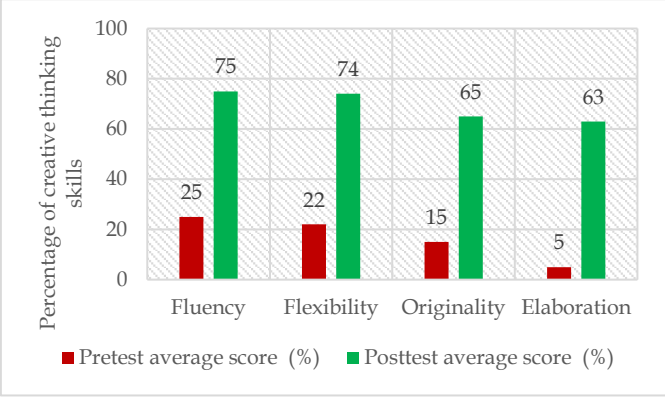

Figure 1. Achievement Scores of Creative Thinking Skills

Figure 1 illustrates that all four indicators of creative thinking skills in Class A achieved scores above 49% after the learning process using the PjBL model. The Elaboration indicator—referring to detailed thinking—achieved the highest level of attainment at 58%, compared to the other indicators. This is because during the learning process, some students began to develop or enrich the ideas of others and outline steps in a detailed manner. Elaborative thinking is demonstrated when students can provide solutions or answers using their own words, offer comprehensive, detailed, and systematic solutions, and generate ideas or solutions that are appropriate based on the available data or information. Questioning is an important cognitive activity that enhances teaching and learning. The quality

of the questions posed by teachers plays a significant role in either stimulating or hindering students' curiosity, thinking, and learning (Salmon & Barrera, 2021). Students' creative thinking skills in the elaboration indicator improved because teachers provided opportunities for students to express answers in their own language, while also requiring those answers to be detailed, in-depth, and systematic—thereby enhancing creative thinking during the learning process. The ability to respond to questions in a detailed and systematic manner contributes to improving students' creative thinking skills in learning (Davies et al., 2013).

The Flexibility indicator achieved a score of 52%, with several students demonstrating the ability to interpret problems in various ways, think of multiple solutions, and classify things into different categories. This is supported by previous research stating that presenting students with problems fosters a responsive learning environment (Wartono et al., 2018). Flexible thinking can also be seen when students offer various answers and form temporary hypotheses in response to problem statements by building upon their prior knowledge (Leasa et al., 2021). Students' creative thinking skills improved through the use of the PjBL model because it provided space for them to express diverse opinions on the problems presented. This allowed students to offer solutions from various perspectives, thereby enhancing their creative thinking skills. Diversity of thought can be developed through learning designs that emphasize exploration and allow students to express their abilities in their own ways (Kwangmuang et al., 2021).

The fluency indicator reached an achievement level of 50%, where some students were already able to provide multiple answers to a question, express their ideas, and critique or give feedback on an argument or issue. Fluent thinking can be observed when students are able to generate ideas or consider multiple solutions to produce relevant concepts by presenting phenomena as the primary learning tool (Arifin et al., 2021). Students' creative thinking skills improved through the PjBL model because, during the learning process, the researcher presented a problem, and students attempted to provide relevant solutions. Problem-solving processes help students generate new ideas and enhance their creative thinking skills as they learn (Aytekin & Topçu, 2024).

The originality indicator also achieved a score of 50%, where some students were able to provide various interpretations of an image and think of ideas that others might not consider. Additionally, students were able to gather information relevant to the problem at hand. Original thinking is demonstrated when students can describe or elaborate in detail by generating new ideas in formulating solutions to a given problem and testing hypotheses related to the problem statement (Segundo-Marcos et al., 2023). Creative thinking skills in the originality indicator improved because students were able to describe new ideas or concepts through stages of problem-solving. They could produce ideas or problem-solving solutions that were innovative and original, thus enhancing their creative thinking skills in learning (Xu et al., 2024).

Based on the results of the t-test analysis, it was found that all four indicators were statistically significant ($p < 0.05$), indicating a significant difference between the pretest and posttest results in terms of creative thinking skills. The average achievement of students' creative thinking skills across the four indicators was 52.5%, categorized as "moderately creative." The results of the study demonstrate that the Project-Based Learning (PjBL) model is reasonably effective in improving creative thinking skills. This aligns with the findings of Fauziah C. et al. (2018), who reported that the Project-Based Learning model is worth considering for application in school learning for other physics topics. Furthermore, data on student learning activities is presented in Figure 2.

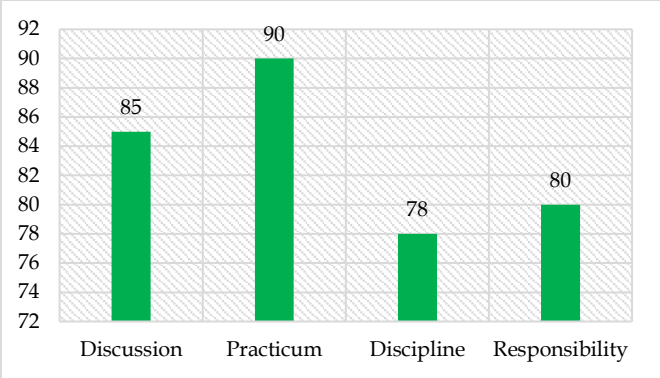

Figure 2. Student Learning Activity Data

Based on Figure 2, it was found that creative thinking skills fostered through the PjBL model can stimulate more active and systematic student learning activities. The average achievement of student learning activity was 83.25%. The discussion indicator reached 85%, the practicum indicator 90%, the discipline indicator 78%, and the responsibility indicator 80%. This result is due to the fact that students were not taught as if pouring water into an empty glass, but rather were guided to search for and discover their own ideas, concepts, or solutions to a problem. As a result, students actively engaged in discussions, became more accustomed to discipline, demonstrated responsibility, and were able to carry out practical activities effectively thanks to facilitation by the researcher. Learning activity refers to any effort made by students to develop

themselves during the learning process (Sakir & Kim, 2020). In this context, with the right instructional approach, student learning activities can trigger the development of creative thinking skills.

Conclusion

Based on the research results using the PjBL model, the following conclusions can be drawn: 1) The achievement of students' creative thinking skills was 52.5%, categorized as moderately creative, with a two-tailed t-test significance of 0.00 across all indicators—fluency, flexibility, originality, and elaboration—indicating a significant difference between pretest and posttest results in measuring creative thinking skills; 2) Students were highly active in learning using the PjBL model, supported by a student learning activity achievement rate of 83.25%.

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The authors declare no conflict of interest

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