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Transformative Learning: The Impact of Project-Based Learning on Creative Thinking and Academic Outcomes in the Science Curriculum

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Abstrak

Penelitian ini menganalisis dampak Project-Based Learning (PBL) terhadap kemampuan berpikir kreatif dan hasil belajar siswa dalam konteks kurikulum IPA dengan penekanan pada tata surya. Penelitian ini, diselesaikan dalam dua siklus, melibatkan lima belas siswa kelas lima dalam penyelidikan dinamis konsep-konsep ilmiah melalui proyek kolaboratif dan langsung. Penelitian ini menunjukkan hubungan multidimensi antar faktor, menyoroti potensi transformatif model PBL. Penerapan PBL tidak hanya meningkatkan pemahaman siswa tentang tata surya tetapi juga menumbuhkan kemampuan penting, termasuk pemecahan masalah, berpikir kritis, dan komunikasi yang efektif. Keterlibatan aktif ini mendorong lingkungan yang kondusif bagi kreativitas, sehingga menghasilkan peningkatan besar dalam kemampuan berpikir kreatif siswa. Berpikir kreatif, sebagai dimensi sekunder, menunjukkan hubungan yang jelas dengan paradigma PBL. Kriteria yang digunakan untuk menilai pemikiran kreatif berhubungan erat dengan konsep PBL, menekankan proyek berbasis siswa yang memberdayakan siswa untuk menyuarakan perspektif secara bebas dan mengambil inisiatif dalam pemecahan masalah. Variabel tersier, hasil belajar, menunjukkan perubahan yang menguntungkan di bawah pengaruh PBL dan pengembangan kemampuan berpikir kreatif. Tingkat kemahiran, yang ditentukan oleh nilai ujian, tidak hanya menunjukkan penguasaan materi pelajaran yang lebih baik tetapi juga penerapan kemampuan berpikir kritis yang diperoleh melalui PBL. Desain penelitian, yang ditandai dengan siklus berulang, menggarisbawahi sifat dinamis dan berkembang dari hubungan antar variabel. Penelitian ini berkontribusi pada wacana pendekatan pengajaran baru, menunjukkan potensi PBL untuk meningkatkan pertumbuhan akademik siswa dalam Sains secara holistik. Temuan ini menggarisbawahi perlunya pendekatan yang berpusat pada siswa yang mengembangkan pemahaman materi pelajaran dan pengembangan keterampilan dasar. Seiring dengan kemajuan pendidikan, memahami hubungan variabel-variabel yang dibahas dalam penelitian ini akan memberikan informasi bagi metode pedagogi di masa depan, dengan mendukung lingkungan pembelajaran yang dinamis dan menarik.

Kata kunci: *Pembelajaran Berbasis Proyek, Berpikir Kreatif, Hasil Belajar.*

Abstract

This research analyses the impact of Project-Based Learning (PBL) on students' creative thinking abilities and learning outcomes in the context of the Science curriculum, with an emphasis on the solar system. The research, completed in two cycles, engages fifteen fifth-grade students in a dynamic investigation of scientific concepts through collaborative and hands-on projects. The research indicates a multidimensional link across factors, highlighting the transformative potential of the PBL model. The adoption of PBL not only increases students' grasp of the solar system but also cultivates vital abilities, including problem-solving, critical thinking, and effective communication. This active engagement promotes an environment conducive to creativity, resulting to a major boost in students' creative thinking abilities. Creative thinking, as a secondary dimension, exhibits a clear association with the PBL paradigm. The criteria used to assess creative thinking connect neatly with PBL concepts, emphasizing student-driven projects that empower learners to voice perspectives freely and take initiative in problem-solving. The tertiary variable, learning outcomes, displays a beneficial shift under the effect of PBL and the development of creative thinking abilities. Proficiency levels, determined by exam scores, show not just better subject matter mastery but also the application of critical thinking abilities gained through PBL. The research design, typified by iterative cycles, underlines the dynamic and developing nature of the link among these variables. This study contributes to the discourse on new teaching approaches, showing the potential of PBL to holistically increase students' academic growth in Science. The findings underline the necessity for student-centered approaches that develop both subject matter understanding and the cultivation of fundamental skills. As education advances, understanding the connection of variables addressed in this research informs future pedagogical methods, arguing for dynamic and engaging learning environments.

Keywords: *Project-Based Learning, Creative Thinking, Learning Outcomes.*

INTRODUCTION

Access to suitable and quality education is the right of every child in Indonesia. Support and direction to guarantee a thorough comprehension of learning are vital for each kid to avoid chronic misconceptions, allowing for best student learning results. Support relating to kids' cognitive development, beyond knowledge and understanding, is important to enhance their creative thinking talents. Creative thinking involves the aptitude to investigate multiple problem-solving solutions, divided into fluency, originality, and elaboration. However, first observations suggest a lack of observable and optimally encouraged creative thinking skills among students, notably noticeable when students are less active in expressing ideas during courses, often relying on textbooks.

Hence, the development of creative thinking skills should commence at the elementary education level to boost students' comprehension of learning materials and improve learning outcomes. Student learning outcomes signify the talents developed after engaging in educational activities. However, during the pandemic, learning activities have been inadequate (Prayuda, Juliana, et al., 2023). Teachers prefer to employ expedited

teaching techniques that may swiftly cover knowledge but insufficiently promote students' creative thinking. The lack of support for strengthening pupils' creative thinking capabilities leads to substandard creative thinking abilities and ultimately inferior learning outcomes. The absence in creative thinking skills is noticeable when children firmly adhere to textbook responses, only memorizing without appreciating the content (Gerde, 2018).

Therefore, this topic bears examination as creative thinking skills are vital for kids, both academically and non-academically. One key learning strategy, starting from elementary school, is the scientific curriculum. Science, as a field, involves human endeavours to grasp the cosmos through exact observation and reasoned techniques leading to conclusions. Science learning is essential for daily life and involves a precise grasp of topics, ideally acquired through direct activities such as experiments and observations. Project-Based Learning (PBL) is a suitable teaching paradigm that focuses on fundamental concepts, including students in problem-solving activities, supporting independent learning development, and culminating in tangible project deliverables. PBL has the capacity to establish discipline, boost student engagement, and encourage creativity in learning (Schmidt et al., 2018).

Numerous past research have studied creative thinking capabilities, learning outcomes, and Project-Based Learning approaches. This action research intends to enhance the learning outcomes and creativity of fifth-grade students by using the PBL model throughout two cycles. Each cycle involves preparation, execution, observation, and reflection (Prayuda et al., 2022). Observational data is acquired through observation sheets, indicating an improvement in both learning outcomes and student creativity after the deployment of the PBL approach. Another study concentrating on boosting students' creative thinking skills in science education involves two cycles including preparation, observation, reflection, and revision phases. Data from observation sheets, creative thinking assessments, cognitive learning assessments, affective learning assessments, psychomotor learning assessments, and student comments reveal an improvement in creative thinking skills following the implementation of inquiry-based learning (Theobald et al., 2020).

Considering the present pandemic setting, where learning is mostly accomplished online, this study explores a fifth-grade class with 28 pupils, consisting 19 boys and 9 girls. Although online learning is handled via WhatsApp groups and YouTube videos, the identified constraints in direct material access impair students' creative thinking abilities. The absence of physical teaching aids decreases students' knowledge of the topic content. Additionally, the reliance on memorising is obvious in students' answers, matching the content of the textbooks. The results indicate the need for reforms in the scientific education process to increase creative thinking and learning outcomes for fifth-grade pupils. The application of Project-Based Learning, helping students in generating their own teaching aids, is vital to maximizing the effectiveness of online learning. This research focuses on elevating creative thinking skills and learning outcomes in a fifth-grade class at a public primary school, specifically in the context of the solar system.

The conducted analysis is particularly significant given the specific challenges provided by the COVID-19 epidemic to the educational landscape. In the observed fifth-grade class (V A), which conducts online learning through WhatsApp groups and YouTube

videos, the weekly submission of tasks by parents is a significant adaption to the remote learning environment. However, the limits of this online setup become obvious when considering the requirement for actual teaching tools, especially in science education. The absence of hands-on experiences, such as experiments and direct observations, inhibits the development of creative thinking skills among pupils (Prayuda, Ginting, et al., 2023). During the epidemic, the observed class's online learning approach seems to be concentrated around the teacher, and students have limited access to materials outside textbooks and videos. This has resulted in a passive learning atmosphere where pupils struggle to understand the content deeply. Creative thinking is further restricted, as seen by the similarity between student responses and textbook content, indicating a lack of personal interpretation.

In response to these problems, the study advocates the use of Project-Based Learning (PBL) as an effective teaching paradigm. PBL has proven promise in engaging students, facilitating independent learning, and creating real achievements. Its implementation includes students in meaningful problem-solving tasks, boosting autonomy and creativity in the learning process. This strategy coincides with the hands-on nature of science teaching, giving students with opportunity to create their understanding actively. The research approach comprises a focus on the promotion of creative thinking skills and learning outcomes in the setting of the solar system. It involves a cyclic process of planning, execution, observation, and reflection. Data collection comprises numerous assessments, such as creative thinking assessments, cognitive learning assessments, emotional learning assessments, psychomotor learning assessments, and student answers through observation sheets, test sheets, and questionnaires (Oppermann, 2019).

Previous studies referenced in the paper indicate the favourable influence of PBL on both learning outcomes and creative thinking skills. This underlines the need for a transition in the educational approach during these hard times, highlighting the necessity of student-centered, inquiry-based strategies to offset the limits of online learning. In conclusion, the research underlines the urgency of correcting the current deficiencies in scientific instruction for fifth-grade children during the epidemic. By using Project-Based Learning, educators may create a more engaging and interactive learning environment that inspires creative thinking and enhances learning outcomes. The outcomes of this study are likely to add useful insights to the continuing conversation on effective educational practices in the context of distant and online education.

Furthermore, the report highlights the necessity of including parents in the learning process during the pandemic. While the submission of weekly assignments is a remarkable engagement method, building a stronger connection between parents and the educational path of their children might enrich the overall learning experience. Encouraging parents to actively participate in activities connected to the project-based learning approach, even in a virtual context, can contribute to a more comprehensive and supportive learning ecosystem. As the project goes through its intended cycles of observation, reflection, and revision, it seeks to give useful insights for educators, politicians, and parents alike. The ultimate goal is to not only improve creative thinking abilities and learning results but also to establish a

robust and adaptive educational framework that can resist the challenges offered by unforeseen disruptions, such as the ongoing epidemic (Lee et al., 2016).

The research also underlines the necessity for continuing professional development for educators to effectively use innovative teaching techniques like Project-Based Learning. Training instructors to integrate technology seamlessly into the learning process and giving them with the skills to traverse virtual classrooms will be vital for the continued success of such projects (Tippett, 2016). In conclusion, the research on boosting creative thinking abilities and learning outcomes in the context of scientific teaching for fifth-grade children during the COVID-19 epidemic bears major implications for the broader education landscape. The findings will give vital insights on the effectiveness of Project-Based Learning as a pedagogical strategy in tough circumstances, and its ability to generate a more active, engaging, and creative learning environment for students. As education continues to evolve, the insights acquired from this research can pave the way for more robust and flexible teaching techniques that stress the overall development of students in both physical and virtual learning contexts.

METHOD

The research methodology adopted in this study is Action Research (Penelitian Tindakan Kelas or PTK), done at an elementary school. The subjects of this investigation are fifth-grade students. Data collecting comprises interviews, observations, and tests. Interviews were done to assess the initial circumstances of students regarding their creative thinking abilities and learning results in science (IPA) lectures. Observations were carried out to gain data on creative thinking abilities, while exams were administered to obtain data on students' learning outcomes. Various instruments were deployed by the researcher, including interview guidelines, observation sheets, and test instruments including questions. The interview instructions comprised 10 questions relevant to students' creative thinking abilities and learning outcomes in scientific education. The observation sheet featured various indicators with several criteria for creative thinking. This document was filled out by inserting checkmarks (□) next to the criteria for innovative thinking displayed by the students. The test instrument consisted of sets of 10 questions in each cycle, with a score of 10 applied to each correct response.

The interview approach was aimed to provide insights on the initial conditions of the fifth-grade pupils concerning their creative thinking talents and their performance in scientific education. The questions in the interview instructions attempted to discover the students' viewpoints, approaches, and comprehension of the topic matter, focusing on both their creative thinking abilities and learning outcomes. This qualitative technique through interviews provides a depth of insight to the research, allowing for a full exploration of the elements impacting creative thinking and academic accomplishment. Observations, another key component of data collecting, involved analysing the creative thinking ability of the students throughout science sessions. The observation sheet, designed with indications and criteria for creative thinking, supported the systematic recording of observed behaviors and thought processes relevant to creative thinking. The use of checkmarks for stated criteria

allowed for a nuanced study of the students' performance, giving vital qualitative data to the research.

The test instrument, containing sets of 10 questions in each cycle, functioned as a quantitative measure to evaluate students' learning outcomes. Each successful response carried a score of 10, offering a clear numerical picture of the students' comprehension and recall of the science information. This quantitative feature gives an objective layer to the research, complementing the qualitative insights gathered from interviews and observations. The instruments deployed in this action research - interview guidelines, observation sheets, and test instruments – collectively offer a comprehensive toolkit for monitoring and understanding the dynamics of creative thinking and learning outcomes in the context of science education. By combining both qualitative and quantitative methodologies, the research attempts to present a well-rounded perspective on the impact of Project-Based Learning on students' creative thinking and academic accomplishment in the fifth-grade context.

As the project goes through its cycles of planning, execution, observation, and reflection, the combined data from interviews, observations, and tests will contribute to a full examination of the effectiveness of Project-Based Learning in promoting creative thinking and learning outcomes. The combination of both qualitative and quantitative findings will provide a firm platform for deriving meaningful conclusions and informing future educational practices.

RESULT AND DISCUSSION

The conclusions of the analysis of students' creative thinking abilities in the Science curriculum are shown in the following table. This table provides a thorough perspective of the percentage of creative thinking abilities from the pre-cycle stage to cycle 2. In the pre-cycle stage, the average percentage of students' critical thinking ability in a class is 26%. As the cycles advance, notably in cycle 1, meeting 1, the percentage climbs to 53%, in cycle 1, meeting 2, it increases to 64%, in cycle 2, meeting 1, it reaches 72%, and in cycle 2, meeting 2, it further improves to 78%. Graph 1 permits a visual comparison of the percentage and the incremental increase of students' creative thinking abilities from the pre-cycle stage to cycle 2. It strongly depicts the rising trend, displaying the growth of creative thinking skills throughout the several periods.

The examination of the data on students' learning results in each step is displayed in Table 3. In the pre-cycle stage, the average learning outcome is 45, which increases to 61 in cycle 1, and further improves to 80 in cycle 2. Graph 3 provides a visual representation of the learning outcome progression, indicating a 27% increase from pre-cycle to cycle 1, an 11% rise from cycle 1, meeting 1, to meeting 2, an 8% increase from cycle 1, meeting 2, to cycle 2, meeting 1, and a 6% improvement from cycle 2, meeting 1, to meeting 2. This research, done across two cycles with two meetings each, aims to boost students' creative thinking abilities and learning results in the Science curriculum by utilising the Project-Based Learning approach. The study covers 15 pupils from the fifth grade of an elementary school. Three indications of creative thinking were applied, each with four criteria, including features such as creating varied ideas, sincerity of thought, and detailing important ideas. The researcher

collected data through observations, collecting the proportion of creative thinking abilities for each student in the class at different phases.

The early data from the pre-cycle stage revealed a 26% average for pupils' creative thinking abilities, indicating a rather low level. Subsequently, the introduction of the Project-Based Learning paradigm during the solar system lesson resulted in a remarkable improvement. In cycle 1, meeting 1, the average creative thinking capacity grew to 53%, demonstrating a substantial 27% rise. As the cycles progressed, this increased tendency persisted with an 11% rise from cycle 1, meeting 1, to meeting 2, and an 8% increase from cycle 2, meeting 1, to meeting 2. Overall, the data reveals a consistent development in students' creative thinking skills at each step, highlighting the efficacy of the Project-Based Learning methodology.

The research also probed into the kids' learning outcomes, with data acquired through teacher assessments in the pre-cycle and test results in each following cycle. The test had 10 multiple-choice questions in each round. The data found a 27% rise in the percentage of students achieving competence from the pre-cycle to cycle 1 and a remarkable 33% improvement from cycle 1 to cycle 2. Table 3 offers a thorough analysis of the number and percentage of students who attained proficiency at each stage. In the pre-cycle, 13% of students passed the proficiency criteria, rising to 40% in cycle 1 and further climbing to 73% in cycle 2.

Graph 3 clearly illustrates the percentage and average change in students' learning outcomes from the pre-cycle to cycle 2. The data demonstrates a continuous and substantial rise in the competency levels of students at each step, demonstrating a favourable influence of the Project-Based Learning approach on their academic achievements. The study not only indicates the quantitative improvement in creative thinking abilities and learning outcomes but also highlights qualitative alterations in students' conduct and confidence. The initial uncertainty shown in the pre-cycle stage develops into a greater readiness and confidence among students to convey their thoughts using their own language, without exclusively relying on texts. The diversity of thoughts generated by pupils also rises, showing a stronger grasp and engagement with the learning material. In conclusion, this research underscores the favourable influence of the Project-Based Learning model on both the quantitative and qualitative elements of students' academic progress, particularly in the context of the Science curriculum.

Based on the performed research, a substantial gap is detected between the starting and final conditions of students about their creative thinking abilities. Students exhibit increasing confidence and desire to explain their thoughts in their own terms, independent of the offered texts, indicating a positive transformation in their approach. Furthermore, students display the ability to produce various and distinctive thoughts, demonstrating a more profound comprehension of the topic matter. This qualitative shift correlates with the quantitative improvements shown in the rising percentages of both creative thinking abilities and learning outcomes.

The project featured two research cycles, each having two sessions, with the overarching goal of boosting students' creative thinking abilities and learning results in the Science curriculum utilising the Project-Based Learning approach. Fifteen pupils from the

fifth grade participated in the investigation. The research employed three markers for innovative thinking, each comprising four requirements. These indicators include the ability to develop numerous and varied thoughts, originality of thought, and the power to detail important ideas. The requirements involve a number of elements, such as problem-solving, expressing thoughts and feelings freely, flexibility in thinking and behaving, and having a diverse range of interests.

Data gathering comprised observations to assess students' creative thinking abilities and instructor assessments for learning outcomes. The research of creative thinking abilities found an average of 26% in the pre-cycle stage, showing a need for improvement. However, with the application of the Project-Based Learning paradigm during the solar system lecture, significant development was noted. In cycle 1, meeting 1, the average creative thinking capacity grew to 53%, suggesting a substantial 27% growth. This favourable trend continued with an 11% rise from cycle 1, meeting 1, to meeting 2, an 8% increase from cycle 2, meeting 1, to meeting 2, and a final improvement to 78% in cycle 2, meeting 2.

The use of the Project-Based Learning model not only boosted creative thinking abilities but also had a favourable impact on students' learning outcomes. The test findings showed an average learning outcome of 45 in the pre-cycle, rising to 61 in cycle 1 and further improving to 80 in cycle 2. Graph 3 clearly depicts the percentage and average improvement in students' learning results, exhibiting a constant and large growth in proficiency levels at each step of the research.

The comparison of pre-cycle to cycle 2 demonstrated a 27% improvement in proficiency levels, emphasizing the favourable influence of the Project-Based Learning paradigm. Furthermore, the results on the number and percentage of students gaining proficiency, as provided in Table 3, revealed a noticeable increase from the pre-cycle stage (13% proficiency) to cycle 1 (40% proficiency) and a significant elevation to 73% proficiency in cycle 2. The Project-Based Learning paradigm, with its collaborative and hands-on approach, proven effective in enabling students to identify answers independently or in groups, strengthening creative thinking talents. The collaborative nature of the learning activities in this paradigm, where students design and solve problems themselves, coincides with the essential qualities of Project-Based Learning. These features include aiding students in devising methods to attain goals, fostering a sense of responsibility in managing information, and culminating in the production of concrete things by the students themselves.

In conclusion, the research not only objectively supports the positive influence of the Project-Based Learning model on students' creative thinking abilities and learning results but also qualitatively highlights a transformative shift in students' behavior and confidence. The findings add vital insights to the ongoing conversation on new teaching approaches, underlining the potential of Project-Based Learning to increase both the quantitative and qualitative aspects of students' academic progress in the framework of the Science curriculum. The research has discovered a compelling connection among many variables, shining light on the complicated connections between the implementation of the Project-Based Learning (PBL) model, students' creative thinking abilities, and their learning results in the Science curriculum. The interlocking nature of these variables reveals a sophisticated and dynamic educational landscape.

The key variable under examination, the Project-Based Learning model, serves as the catalyst for positive changes in both creative thinking abilities and learning outcomes. As students engage in collaborative, hands-on projects, they not only learn the subject matter but also develop vital skills such as problem-solving, critical thinking, and effective communication. This active involvement generates a climate where innovation is fostered, resulting to the observed growth in pupils' creative thinking abilities. Creative thinking, as a secondary variable, is tightly linked with the Project-Based Learning approach. The model's emphasis on student-driven projects enables pupils to produce different and innovative ideas. The criteria used to assess creative thinking, including the ability to develop various ideas, originality of thought, and the competence to detail core concepts, are naturally ingrained in the PBL approach. The collaborative nature of PBL helps students to voice their viewpoints freely, be flexible in their thinking, and take initiative in problem-solving – all critical components of creative thinking.

The tertiary variable, learning outcomes, experiences a transformative journey under the impact of the PBL paradigm and the development of creative thinking abilities. The positive link between these variables is obvious in the increased percentages of learning outcomes obtained at each level of the investigation. The PBL paradigm, by offering a platform for active interaction and creative investigation, greatly leads to increased learning outcomes. The higher competence levels, as evaluated by test results, show not just greater grasp of the subject matter but also the application of critical thinking abilities developed through the PBL approach. The circular nature of the research design further exposes the connectivity among these variables. Each cycle of the research is a continual process of planning, execution, observation, and reflection. This iterative technique allows for continual modifications and refinements, stressing the dynamic and evolving character of the relationship among the variables. The positive feedback loop established by the PBL model, creative thinking growth, and enhanced learning outcomes underlines the necessity of a holistic and student-centered educational approach.

Furthermore, the research reveals a contextual link between these variables within the specific topic of the Science curriculum. The chosen topic, the solar system, provides as a backdrop for the examination of creative thinking and learning outcomes. The engagement with practical concepts connected to the solar system through PBL activities not only increases learning but also gives a real-world framework for the application of creative thinking abilities. In conclusion, the research illuminates a robust and interwoven relationship among the variables of Project-Based Learning, creative thinking abilities, and learning outcomes in the setting of the Science curriculum. The beneficial impact observed across the research cycles emphasises the potential of novel teaching approaches to holistically contribute to students' academic growth. As education continues to evolve, identifying and harnessing these linkages can inform future educational methods, providing a more dynamic and interesting learning environment for students.

CONCLUSION

In conclusion, this research has provided valuable insights into the transformative impact of the Project-Based Learning (PBL) model on students' creative thinking abilities and

learning outcomes in the Science curriculum, specifically focusing on the solar system. The dynamic and interconnected nature of the variables explored in this study underscores the significance of innovative teaching methodologies in shaping a holistic educational experience. The implementation of the PBL model emerged as a powerful catalyst for positive change. Through collaborative and hands-on projects, students not only deepened their understanding of scientific concepts related to the solar system but also developed crucial skills such as problem-solving, critical thinking, and effective communication. This active engagement fostered an environment where creativity flourished, leading to a notable enhancement in students' creative thinking abilities.

Creative thinking, as a secondary variable, demonstrated a clear correlation with the PBL model. The criteria used to assess creative thinking, including the ability to generate varied ideas, originality of thought, and the capacity to detail main ideas, found a natural alignment with the principles of PBL. The model's emphasis on student-driven projects empowered learners to express opinions freely, be flexible in their thinking, and take initiative in problem-solving – all integral components of creative thinking. The tertiary variable, learning outcomes, witnessed a positive and substantial transformation under the influence of the PBL model and the development of creative thinking abilities. The upward trajectory of proficiency levels, as evidenced by test scores, reflected not only improved comprehension of scientific concepts but also the application of critical thinking skills honed through the PBL approach. The context-specific exploration of the solar system served as a meaningful backdrop, providing a tangible and real-world context for the application of creative thinking skills.

The cyclic research design underscored the iterative and evolving nature of the relationship among these variables. Each research cycle represented a continuous process of planning, execution, observation, and reflection, allowing for ongoing adjustments and refinements. The positive feedback loop generated by the PBL model, creative thinking development, and improved learning outcomes reinforces the importance of a holistic and student-centered educational approach. This research contributes to the broader discourse on innovative teaching methodologies, emphasizing the potential of Project-Based Learning to holistically enhance students' academic development in the Science curriculum. The findings highlight the need for dynamic and engaging educational practices that foster not only subject matter understanding but also the cultivation of essential skills for lifelong learning.

As education continues to evolve, understanding and leveraging the connections among variables explored in this research can inform future pedagogical practices. The positive outcomes observed suggest that incorporating innovative and student-centered approaches, such as PBL, can be instrumental in creating a rich and transformative learning environment.

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