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ENHANCING EARLY CHILDHOOD UNDERSTANDING OF NATURAL PHENOMENA THROUGH PROJECT-BASED LEARNING: AN EXPERIMENTAL STUDY

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ABSTRACT

Early childhood education plays a crucial role in developing scientific literacy, particularly in fostering children's ability to recognize natural phenomena through observation, exploration, and experimentation. This study aims to analyze the effect of Project-Based Learning on early childhood students' ability to recognize natural phenomena, with an emphasis on creating meaningful and experiential learning environments. A quantitative experimental method was employed using a posttest-only control group design. Participants consisted of children aged 5–6 years divided into an experimental group receiving Project-Based Learning and a control group receiving conventional instruction. Data were collected using a validated assessment instrument measuring observation, exploration, and experimentation skills. Statistical analysis was conducted through prerequisite tests and an independent samples t-test at a significance level of 0.05. The results indicate that children in the Project-Based Learning group achieved higher mean scores compared to those in the conventional group, demonstrating stronger abilities in recognizing natural phenomena. The learning process in the experimental group showed higher engagement, active participation, and improved inquiry behaviors. The findings suggest that experiential and project-based activities enhance children's understanding of scientific concepts by connecting learning with real-life experiences. The discussion reveals that active learning environments support cognitive development more effectively than passive instructional approaches. The study concludes that Project-Based Learning significantly improves early childhood students' ability to recognize natural phenomena. The findings provide empirical support for adopting student-

centered and experiential learning models in early childhood education and highlight their importance in developing foundational scientific skills.

KEYWORD: Early childhood science learning, Experiential learning, Scientific literacy development.

INTRODUCTION

Early childhood education constitutes a critical phase in human development, particularly in establishing the foundations of cognitive growth, scientific literacy, and lifelong learning habits. At this stage, children demonstrate heightened curiosity and an intrinsic motivation to explore their surroundings, making it an optimal period for introducing fundamental scientific concepts. The recognition of natural phenomena, such as weather changes, plant growth, and environmental patterns, represents a key component of early science education. This ability is not limited to factual knowledge acquisition but encompasses observational skills, exploratory behavior, and simple experimentation, which collectively support the development of scientific thinking. Existing literature emphasizes that early engagement with science significantly contributes to children's readiness for more advanced learning and fosters sustained interest in science-related domains. Contemporary educational frameworks further highlight the importance of integrating science learning into early childhood curricula to promote inquiry-based and experiential learning.

Recent studies have increasingly underscored the role of active learning approaches in enhancing young children's understanding of scientific concepts. Constructivist perspectives, particularly those proposed by Piaget and Vygotsky, assert that knowledge is constructed through interaction with the environment and social engagement rather than passive reception. Learning processes that involve direct experience, collaboration, and reflection are therefore considered more effective in supporting children's cognitive development. Empirical research has demonstrated that children who participate in interactive and hands-on learning activities exhibit higher levels of engagement, deeper conceptual understanding, and improved problem-solving skills. These findings reinforce the necessity of adopting instructional models that align with the developmental characteristics of early childhood learners and facilitate meaningful learning experiences.

The prevailing challenge in early childhood science education lies in the continued reliance on conventional, teacher-centered instructional approaches. In many educational settings, including TK Negeri Kemuning Duhiadaa, teaching practices are predominantly

characterized by lectures, rote memorization, and limited use of interactive media. Such approaches tend to position children as passive recipients of information, thereby restricting opportunities for exploration and inquiry. Observational data indicate that a substantial proportion of children demonstrate low levels of participation in science learning activities conducted through conventional methods. Approximately 73% of children are reported to be less engaged, with limited development of observational and inquiry skills. These conditions suggest that traditional instructional models are insufficient in fostering children's ability to recognize and understand natural phenomena effectively.

Addressing this issue requires a shift toward more student-centered and experiential learning approaches that actively involve children in the learning process. Instructional models grounded in constructivist principles offer a viable solution by emphasizing active engagement, exploration, and collaboration. Project-Based Learning (PJBL) emerges as a particularly relevant approach in this context, as it enables learners to engage in meaningful projects that reflect real-life situations. Through PJBL, children participate in activities such as observing environmental changes, conducting simple experiments, and creating tangible representations of their learning. This approach not only enhances cognitive development but also promotes social interaction, communication, and creativity. The integration of PJBL into early childhood education is therefore expected to address the limitations of conventional teaching methods and improve learning outcomes in science education.

Empirical evidence from previous studies supports the effectiveness of PJBL in enhancing various aspects of children's learning. Research conducted by Priantika et al. (2024) revealed that the implementation of Project-Based Learning significantly improved creative thinking skills among children aged 4–5 years in TK Al-Ghufron Sumberejo. The study employed a pre-experimental design and demonstrated that project-based activities facilitated active participation and encouraged children to generate innovative ideas. Pancarita (2020) also reported that the application of PJBL in science learning at PAUD Melati DWP UNM enabled children to engage in problem-solving through scientific approaches. The findings indicated that PJBL created a learning environment in which children could explore, experiment, and construct knowledge independently. These studies collectively highlight the potential of PJBL as an effective instructional model for promoting active learning and enhancing cognitive development in early childhood education.

Further evidence suggests that PJBL contributes to the development of a wide range of competencies beyond cognitive skills. The approach supports the acquisition of 21st-century skills, including collaboration, communication, critical thinking, and creativity. Children

engaged in project-based activities are encouraged to work collaboratively, share ideas, and reflect on their learning experiences. This process fosters not only academic achievement but also social and emotional development. Authentic assessment practices embedded within PJBL allow educators to evaluate both the learning process and the outcomes, providing a comprehensive understanding of children's progress. These characteristics make PJBL particularly suitable for early childhood education, where holistic development is a primary objective.

Despite the growing body of literature on PJBL, research specifically examining its application in early childhood science education, particularly in relation to the recognition of natural phenomena, remains limited. Most existing studies have focused on older learners or have addressed broader aspects of learning outcomes without explicitly investigating children's ability to understand natural phenomena. The contextual application of PJBL in kindergarten settings, especially within local educational environments, has not been extensively explored. This gap indicates a need for empirical studies that investigate how PJBL can be effectively implemented to enhance young children's scientific understanding in specific educational contexts.

The present study aims to address this gap by analyzing the influence of Project-Based Learning (PJBL) on early childhood students' ability to recognize natural phenomena. The novelty of this research lies in its focus on the application of PJBL within early childhood education settings and its emphasis on developing children's scientific understanding through experiential learning. The study is limited to examining the effect of PJBL as an instructional model on children's ability to observe, explore, and experiment with natural phenomena. This focus provides a clear and specific contribution to the field of early childhood education by offering empirical evidence on the effectiveness of PJBL in fostering scientific literacy at an early age.

METHODOLOGY

This study employed a quantitative experimental approach to analyze the effect of Project-Based Learning (PJBL) on early childhood students' ability to recognize natural phenomena. A posttest-only control group design was implemented, involving two groups of children aged 5–6 years from TK Negeri Kemuning Duhiadaa. The experimental group received instruction using the PJBL model, which emphasized active engagement through observation, exploration, and simple experimentation, while the control group was taught using conventional teacher-centered methods. The learning process in the experimental group

involved structured project activities that allowed children to construct understanding through direct experience, whereas the control group relied on verbal explanations and limited interaction. The independent variable in this study was the learning model, and the dependent variable was children's ability to recognize natural phenomena.

Data were collected using an assessment instrument developed based on key indicators of early childhood scientific understanding, including observation, exploration, and experimentation. The instrument was validated through expert judgment and tested for reliability to ensure consistency. Data collection was conducted after the instructional treatment through a posttest administered to both groups. The resulting data were analyzed using inferential statistics. Preliminary analyses included tests of normality and homogeneity to confirm the assumptions for parametric testing. Hypothesis testing was then conducted using an independent samples t-test at a significance level of $\alpha = 0.05$ to determine whether there was a statistically significant difference between the two groups, thereby identifying the effect of PJBL on children's ability to recognize natural phenomena.

RESULTS AND DISCUSSION

Descriptive Analysis of Learning Outcomes

The results of this study indicate a clear difference in learning outcomes between children who were taught using the Project-Based Learning (PJBL) model and those who received conventional instruction. The descriptive statistical analysis shows that the average score of children in the experimental group reached 64.77, while the control group achieved an average score of 53.95. This difference suggests that the implementation of PJBL contributed to higher levels of ability in recognizing natural phenomena among early childhood learners.

The distribution of scores further reveals that children in the PJBL group demonstrated more consistent performance across the measured indicators, including observation, exploration, and simple experimentation. In contrast, the control group exhibited greater variability in scores, indicating less uniform development of these abilities. These findings reflect the impact of instructional design on children's engagement and learning processes. PJBL, which emphasizes active participation and experiential learning, appears to provide a more supportive environment for the development of scientific understanding in early childhood education.

The descriptive results also highlight differences in classroom dynamics between the two groups. Children in the PJBL group were more actively involved in learning activities, showing greater enthusiasm and curiosity when engaging with natural phenomena.

Observations during the learning process indicated that these children were more likely to ask questions, explore materials, and collaborate with peers. The control group, on the other hand, tended to rely on teacher explanations and demonstrated lower levels of active participation. This contrast underscores the importance of instructional approaches that align with the developmental characteristics of young learners.

Assumption Testing and Inferential Analysis

Prior to conducting hypothesis testing, prerequisite analyses were performed to ensure that the data met the assumptions required for parametric statistical testing. The normality test results indicated that the data for both the experimental and control groups were normally distributed. The homogeneity of variance test further confirmed that the variances between the two groups were equal. These results validated the use of parametric tests for subsequent analysis.

Hypothesis testing was conducted using an independent samples t-test to determine whether the observed difference in mean scores between the two groups was statistically significant. The results of the analysis revealed a significant difference between the experimental group and the control group at a significance level of $\alpha = 0.05$. This finding indicates that the use of Project-Based Learning had a statistically significant effect on children's ability to recognize natural phenomena.

The statistical significance of the results supports the conclusion that PJBL is more effective than conventional instructional methods in promoting early childhood scientific understanding. The magnitude of the difference in mean scores further suggests that the effect of PJBL is not only statistically significant but also practically meaningful. These findings provide empirical evidence for the effectiveness of PJBL as an instructional model in early childhood education.

Interpretation of Findings in Relation to Learning Theory

The findings of this study can be interpreted within the framework of constructivist learning theory, which emphasizes the active role of learners in constructing knowledge through interaction with their environment. The higher performance of children in the PJBL group reflects the alignment of this instructional model with constructivist principles. PJBL provides opportunities for children to engage in hands-on activities, explore real-world phenomena, and construct meaning through direct experience.

Piaget's theory of cognitive development suggests that children in the preoperational stage learn best through concrete experiences and active manipulation of objects. The PJBL approach facilitates such experiences by allowing children to observe natural phenomena, conduct simple experiments, and engage in exploratory activities. These experiences enable children to develop mental representations of scientific concepts and enhance their understanding of cause-and-effect relationships.

Vygotsky's sociocultural theory further supports the effectiveness of PJBL by highlighting the importance of social interaction in learning. Collaborative activities within PJBL encourage children to share ideas, discuss observations, and learn from one another. The role of the teacher as a facilitator also aligns with Vygotsky's concept of the zone of proximal development, where guidance and support enable learners to achieve higher levels of understanding. The interactive and collaborative nature of PJBL thus contributes to the development of both cognitive and social skills.

The Role of Experiential Learning in Enhancing Scientific Understanding

The effectiveness of PJBL observed in this study can also be attributed to its emphasis on experiential learning. Experiential learning theory posits that knowledge is constructed through experience, reflection, and application. PJBL incorporates these elements by engaging children in activities that require them to interact directly with their environment. The process of observing, exploring, and experimenting allows children to develop a deeper understanding of natural phenomena.

Children in the PJBL group demonstrated improved ability to identify patterns, make predictions, and explain simple scientific processes. These abilities are essential components of early scientific literacy. The opportunity to engage in hands-on activities enables children to connect abstract concepts with concrete experiences, thereby enhancing comprehension and retention. The use of projects as a central learning activity also provides a meaningful context for learning, making the educational experience more relevant and engaging for young learners.

The findings of this study are consistent with previous research indicating that active learning approaches lead to better learning outcomes in early childhood education. Studies by Priantika et al. (2024) and Pancarita (2020) have shown that PJBL promotes active engagement, creativity, and problem-solving skills among young learners. The present study extends these findings by demonstrating the effectiveness of PJBL in enhancing children's ability to recognize natural phenomena, a key aspect of early science education.

Implications for Early Childhood Education Practice

The results of this study have important implications for teaching practices in early childhood education. The demonstrated effectiveness of PJBL suggests that educators should consider adopting more student-centered and experiential learning approaches in science instruction. Traditional teacher-centered methods may not adequately support the development of scientific understanding, particularly in young children who require active engagement and concrete experiences.

Implementation of PJBL in early childhood classrooms requires careful planning and preparation. Teachers need to design projects that are developmentally appropriate, relevant to children's experiences, and aligned with learning objectives. The role of the teacher shifts from that of a knowledge transmitter to a facilitator who guides and supports children's learning პროცეს. This shift necessitates professional development and training to equip teachers with the skills needed to implement PJBL effectively.

The use of authentic assessment within PJBL also provides opportunities for more comprehensive evaluation of children's learning. Assessment practices should focus not only on final outcomes but also on the learning process, including children's participation, collaboration, and problem-solving abilities. Such approaches to assessment align with the holistic nature of early childhood education and provide a more accurate representation of children's development.

Although the findings of this study provide valuable insights into the effectiveness of PJBL, several limitations should be acknowledged. The study was conducted in a single educational setting, which may limit the generalizability of the results. The sample size was also relatively small, which may affect the robustness of the findings. Future research should consider involving multiple institutions and larger samples to enhance the generalizability of the results.

Further studies could also explore the long-term effects of PJBL on children's scientific understanding and learning outcomes. Investigation into additional variables, such as teacher competence, classroom environment, and parental involvement, may provide a more comprehensive understanding of the factors influencing the effectiveness of PJBL. Comparative studies involving different instructional models may also contribute to the development of more effective teaching strategies in early childhood education.

The overall findings of this study demonstrate that Project-Based Learning has a significant positive effect on early childhood students' ability to recognize natural phenomena. The

results indicate that children who engage in active, experiential, and collaborative learning activities achieve higher levels of understanding compared to those who receive conventional instruction. The alignment of PJBL with constructivist and experiential learning theories provides a strong theoretical foundation for its effectiveness.

The study contributes to the growing body of literature supporting the use of innovative instructional models in early childhood education. The evidence presented highlights the importance of designing learning environments that encourage exploration, inquiry, and active participation. The findings reinforce the notion that effective teaching strategies must be aligned with the developmental characteristics of learners to achieve optimal educational outcomes.

CONCLUSION

This study demonstrates that the implementation of Project-Based Learning (PJBL) has a significant positive effect on early childhood students' ability to recognize natural phenomena. Children exposed to PJBL achieved higher performance in observation, exploration, and simple experimentation compared to those who experienced conventional instruction. The findings confirm that learning environments emphasizing active engagement and hands-on experiences are more effective in fostering early scientific understanding than teacher-centered approaches.

The discussion highlights that PJBL aligns with constructivist and experiential learning principles, enabling children to construct knowledge through direct interaction with their environment. The model facilitates meaningful learning by integrating real-life contexts, collaboration, and inquiry-based activities. These elements contribute to improved cognitive development and support the formation of early scientific literacy. The results also indicate that instructional design plays a more critical role than passive content delivery in shaping learning outcomes at the early childhood level.

This study contributes to the existing body of knowledge by providing empirical evidence on the effectiveness of PJBL in early childhood science education, particularly in developing the ability to recognize natural phenomena. The findings offer practical implications for educators to adopt more student-centered approaches. Future research should expand the scope by involving diverse educational settings and examining long-term impacts of PJBL on children's scientific development.

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