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APPLICATION OF DEEP LEARNING MODEL IN IMPROVING EARLY CHILDHOOD DEVELOPMENT

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Abstract

Background: *Cognitive development is an essential aspect of early childhood education as it underpins children's abilities in thinking, reasoning, problem-solving, and decision-making that support lifelong learning. The Deep Learning model, which integrates mindful, meaningful, and joyful learning principles, is an innovative approach designed to enhance children's engagement and learning experiences. However, empirical evidence on its effectiveness in relation to cognitive development in real kindergarten settings remains limited.* ***Objective:*** *This study aimed to analyze the relationship between the implementation of the Deep Learning model and the cognitive development of children aged 4–6 years at Cemara Liliba Kindergarten, Kupang City. Method: This quantitative study used an ex post facto design involving 20 children selected through purposive sampling. Data were collected through observation, interviews, documentation, and cognitive development assessments, then analyzed using descriptive statistics and simple linear regression with SPSS.* ***Results:*** *The findings indicated that the Deep Learning model encouraged active participation, curiosity, and enjoyable learning experiences among children through mindful, meaningful, and joyful activities. However, the regression analysis showed that the relationship between the Deep Learning model and cognitive development was not statistically significant ($p > 0.05$). The coefficient of determination ($R^2 = 0.088$) revealed that only 8.8% of cognitive development variance was explained by the model, while 91.2% was influenced by other factors.* ***Novelty:*** *This study provides empirical evidence of Deep Learning implementation in early childhood classrooms using an ex post facto design.* ***Conclusion:*** *The Deep Learning model created positive learning experiences but did not significantly affect children's cognitive development.*

Keywords: *Deep Learning Model; Cognitive Development; Early Childhood Education; Ex Post Facto; Kindergarten.*

INTRODUCTION

Early childhood education (ECE) is a fundamental stage in human development because it provides educational stimulation that supports children's physical, motor, cognitive, language, social-emotional, artistic, and moral development during the golden age, namely from birth to six years of age. At this stage, appropriate educational experiences play an important role in maximizing children's developmental potential and preparing them for further education (Amseke, 2023). Among these developmental domains, cognitive development is considered one of the most essential because it forms the foundation for children's ability to think, reason, solve problems, and understand concepts required for lifelong learning.

Cognitive development refers to children's mental processes in acquiring knowledge, processing information, remembering experiences, and solving problems. According to Piaget (as cited in Santrock, 2011), children aged 4–6 years are in the preoperational stage, during which symbolic thinking, imagination, language development, and simple reasoning rapidly develop. Consequently, children require learning experiences that actively engage them in exploration, experimentation, and meaningful interaction rather than passive knowledge reception. In Indonesia, the National Standard for Early Childhood Education also emphasizes that children aged 5–6 years should demonstrate the ability to recognize numbers, classify objects, understand patterns, solve simple problems, and explain simple cause-and-effect relationships.

However, many early childhood institutions continue to experience difficulties in optimizing children's cognitive development. Previous studies reported that numerous children still experience limitations in recognizing mathematical concepts, maintaining attention, remembering information, and solving simple problems because classroom instruction remains teacher-centered and relies heavily on worksheets and repetitive activities (Hidayati et al., 2023; Fauziyah & Rohyani, 2023). These conventional instructional practices provide limited opportunities for children to actively construct knowledge through meaningful learning experiences, resulting in less optimal cognitive development.

To address these challenges, the Indonesian Ministry of Primary and Secondary Education has introduced the Deep Learning Learning Approach as an educational paradigm emphasizing Mindful, Meaningful, and Joyful Learning. Unlike artificial intelligence-based deep learning, this educational approach focuses on creating learning experiences that encourage students to learn consciously, understand concepts meaningfully, and enjoy the learning process through active participation and authentic experiences. This approach encourages teachers to facilitate inquiry-based, collaborative, and experiential learning activities that stimulate children's curiosity, creativity, and higher-order thinking skills.

Several previous studies have demonstrated that meaningful and student-centered learning approaches positively influence children's cognitive development. Maulidah and Sari (2023) reported that active learning significantly improved children's problem-solving and conceptual understanding. Similarly, Yuliani and Hasibuan (2024) found that child-centered learning activities increased children's cognitive achievement through exploration and interactive experiences. Nevertheless, previous studies have generally focused on active learning strategies without specifically investigating the implementation of the Deep Learning Learning Approach based on the principles of Mindful, Meaningful, and Joyful Learning in Indonesian early childhood classrooms. Therefore, empirical evidence regarding the effectiveness of this approach remains limited.

Cemara Liliba Kindergarten in Kupang City faces similar challenges in improving children's cognitive development. Based on preliminary observations, many children still experience difficulties in recognizing numbers, classifying objects, identifying patterns, and solving simple problems independently. Classroom instruction is still predominantly teacher-centered, with learning activities relying on explanation and worksheet completion, thereby limiting children's opportunities to actively explore and construct knowledge. These conditions indicate the need for a more innovative learning approach capable of facilitating active engagement and meaningful learning experiences.

Interviews conducted with classroom teachers further revealed that children tend to become more enthusiastic, curious, and actively involved when learning activities incorporate exploration, games, and problem-solving tasks. Teachers also reported improvements in children's concentration, questioning ability, and confidence when implementing learning activities aligned with the principles of Mindful, Meaningful, and Joyful Learning. These findings suggest that the Deep Learning Learning Approach has considerable potential to enhance children's cognitive development in early childhood education.

Despite the increasing implementation of the Deep Learning Learning Approach in Indonesian schools, empirical studies examining its effectiveness in improving cognitive development among children aged 4–6 years remain scarce, particularly in East Nusa Tenggara. This gap highlights the need for research that provides empirical evidence regarding the effectiveness of this learning approach in early childhood settings.

Therefore, this study aims to examine the effect of the Deep Learning Learning Approach on the cognitive development of children aged 4–6 years at Cemara Liliba Kindergarten, Kupang City. The findings are expected to contribute theoretically to the development of early childhood learning models and practically provide recommendations for teachers in implementing meaningful, mindful, and joyful learning experiences that optimize children's cognitive development.

METHODS

This study employed a quantitative approach using an ex post facto research design to examine the relationship between the implementation of the Deep Learning model and the cognitive development of children aged 4–6 years at Cemara Liliba Kindergarten, Kupang City. An ex post facto design was selected because the researcher did not manipulate the independent variable but examined the existing implementation of the Deep Learning model and its relationship with children's cognitive development in a natural classroom setting. The study involved 20 children aged 4–6 years who were selected using **purposive sampling** based on the criteria that the children actively participated in classroom learning activities and had completed the cognitive learning program during the research period.

The independent variable in this study was the implementation of the Deep Learning model, which consisted of the dimensions of mindful learning, meaningful learning, and joyful learning, while the dependent variable was children's cognitive development. The research instruments consisted of observation sheets, interview guidelines, documentation, and cognitive development assessment instruments developed based on indicators of early childhood cognitive development and the principles of the Deep Learning model. Prior to data collection, the research instruments were reviewed to ensure their relevance to the research objectives and the characteristics of early childhood learners.

Data collection was carried out through classroom observations, interviews with teachers, documentation, and cognitive development assessments. Observations were conducted to identify the implementation of the Deep Learning model during classroom activities, while interviews were used to obtain supporting information regarding children's learning experiences and cognitive development. Documentation was used to support the observation findings and provide additional evidence related to the learning process.

The collected data were analyzed using descriptive statistics and simple linear regression with the assistance of SPSS version 25. Descriptive statistics were used to describe the implementation of the Deep Learning model and the level of children's cognitive development, whereas simple linear regression was employed to examine the relationship between the independent and dependent variables. Statistical significance was determined at the 0.05 level.

To strengthen the theoretical foundation of the study, relevant scientific literature published between 2021 and 2025, including national and international journal articles, books, and previous research, was reviewed. According to Creswell and Creswell (2021), the selection of literature sources should consider relevance, credibility, and currency to ensure a strong scientific basis for research. Therefore, the literature review in this study served to support the conceptual framework and interpretation of the findings rather than as the primary research method.

Through this methodological approach, the study is expected to provide empirical evidence regarding the implementation of the Deep Learning model and its relationship with the cognitive development of early childhood, as well as to contribute practical recommendations for educators in designing meaningful, mindful, and joyful learning experiences.

RESULTS AND DISCUSSION

RESULTS

1. Descriptive Statistics of the Deep Learning Model

To provide an overview of the implementation of the Deep Learning model at Cemara Liliba Kindergarten, a descriptive statistical analysis was conducted. The scores obtained from the Deep Learning questionnaire were classified into three categories, namely high, moderate, and low, based on predetermined score intervals. This descriptive analysis aims to identify the distribution of children's participation in learning activities designed according to the principles of Deep Learning, including Mindful Learning, Meaningful Learning, and Joyful Learning. The findings provide an initial description of how well the learning model has been implemented before examining its relationship with children's cognitive development through inferential statistical analysis.

Table 1. Distribution of Deep Learning Model Categories

Category	Interval	Frequency	Percentage
High	59–41	6	30%
Moderate	40–22	11	55%
Low	21–3	3	15%
Total		20	100%

Based on Table 1, the distribution of Deep Learning implementation among the twenty participating children indicates that 6 children (30%) were classified in the high category, 11 children (55%) were in the moderate category, and 3 children (15%) were in the low category. The moderate category accounted for the largest proportion of participants, indicating that most children demonstrated an adequate level of engagement in learning activities designed using the Deep Learning approach. Meanwhile, approximately one-third of the participants achieved the high category, reflecting strong involvement during classroom learning. Only a small proportion of children remained in the low category, suggesting that although the implementation of the learning model has generally been satisfactory, some children still require additional support and learning stimulation to achieve a higher level of participation.

The descriptive findings indicate that the implementation of the Deep Learning model has been carried out consistently across the learning activities at Cemara Liliba Kindergarten. Most children actively participated in classroom activities and demonstrated satisfactory engagement throughout the learning process. However, the variation in category distribution suggests that children's responses to the learning approach were not entirely uniform. Individual differences in learning readiness, classroom participation, and learning experiences may contribute to these variations. Therefore, although the overall implementation of the Deep Learning model can be categorized as moderate to high, further analysis is required to determine whether these differences significantly influence children's cognitive development.

2. **Descriptive Statistics of Cognitive Development**

Following the analysis of the Deep Learning model, descriptive statistics were also performed to examine the level of cognitive development among children aged 4–6 years at Cemara Liliba Kindergarten. The assessment of cognitive development was conducted using observation-based instruments covering several indicators of early childhood cognitive abilities, including recognizing numbers, classifying objects, identifying patterns, solving simple problems, and demonstrating logical thinking during classroom activities. Similar to the previous analysis, the obtained scores were grouped into high, moderate, and low categories to describe the overall cognitive achievement of the participants.

Table 2. Distribution of Cognitive Development Categories

Category	Interval	Frequency	Percentage
High	53–47	7	35%
Moderate	46–40	9	45%
Low	39–33	4	20%
Total		20	100%

Table 2 shows that cognitive development among the research participants varied across the three established categories. Seven children (35%) were categorized as having high cognitive development, nine children (45%) were classified in the moderate category, and four children (20%) were included in the low category. The moderate category represented the largest percentage of participants, indicating that nearly half of the children demonstrated cognitive abilities appropriate for their developmental stage. In contrast, one-fifth of the participants remained in the low category, suggesting that some children still experienced challenges in achieving optimal cognitive performance according to the assessment indicators used in this study.

The descriptive analysis further demonstrates that the majority of children have developed cognitive skills at a satisfactory level, although variations among participants are still evident. Children classified in the high category generally demonstrated better performance in recognizing concepts, understanding relationships among objects, following learning instructions, and solving simple problems encountered during classroom activities. Conversely, children in the low category required additional guidance and learning support to improve their cognitive abilities. Overall, these findings indicate that cognitive development among children at Cemara Liliba Kindergarten is relatively diverse, thereby providing an important basis for further statistical analysis examining the relationship between the implementation of the Deep Learning model and children's cognitive development.

3. Simple Linear Regression Analysis

To determine whether the implementation of the Deep Learning model significantly influenced the cognitive development of children aged 4–6 years at Cemara Liliba Kindergarten, a simple linear regression analysis was performed using IBM SPSS Statistics version 25. Before interpreting the regression model, the overall significance of the model was evaluated using the Analysis of Variance (ANOVA) test. The ANOVA test determines whether the independent variable, namely the Deep Learning model, significantly predicts the dependent variable, namely children's cognitive development.

Table 3. ANOVA Results of the Simple Linear Regression Model

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	33.782	1	33.782	1.744	0.203
Residual	348.668	18	19.370		
Total	382.450	19			

Based on Table 3, the simple linear regression analysis produced an F-value of **1.744** with a significance value (Sig.) of 0.203. Since the obtained significance value is greater than the predetermined significance level of 0.05 (0.203 > 0.05), the regression model is not statistically significant. Therefore, the null hypothesis (H_0) is accepted, indicating that the Deep Learning model did not significantly predict children's cognitive development in this study. These findings suggest that the variation observed in children's cognitive development cannot be explained solely by the implementation of the Deep Learning model. Although the regression coefficient showed a positive direction, the statistical evidence indicates that the observed relationship was not sufficiently strong to reach the required level of significance.

The ANOVA results also indicate that additional variables beyond the scope of this study may contribute to differences in children's cognitive development. Factors such as children's developmental readiness, family educational support, classroom environment, instructional practices, previous learning experiences, and individual characteristics may have influenced the observed outcomes. Consequently, the Deep Learning model alone was insufficient to explain the variation in cognitive achievement among the research participants.

4. Coefficient of Determination (Model Summary)

Following the regression significance test, the coefficient of determination (R^2) was calculated to determine the proportion of variance in cognitive development explained by the Deep Learning model. The Model Summary provides information regarding the strength of the relationship between the independent and dependent variables and the predictive ability of the regression model.

Table 4. Model Summary of the Simple Linear Regression Analysis

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.297	0.088	0.038	4.4017

Table 4 indicates that the correlation coefficient (R) between the Deep Learning model and children's cognitive development was 0.297, reflecting a weak positive relationship between the two variables. The coefficient of determination (R Square**)** was 0.088**,** indicating that the Deep Learning model explained only 8.8% of the variance in children's cognitive development. The remaining 91.2**%** of the variance was attributable to other variables that were not included in the present study. Furthermore, the Adjusted R Square value of 0.038 demonstrates that, after adjusting for the number of observations and predictors, the explanatory power of the regression model remained relatively low.

The standard error of the estimate was 4.4017**,** indicating the average prediction error generated by the regression model. Collectively, these statistical indicators demonstrate that although a positive relationship exists between the Deep Learning model and children's cognitive development, the magnitude of the relationship is relatively weak. Consequently, the Deep Learning model contributed only a small proportion of the observed variability in cognitive development among the participants.

5. Partial Regression Analysis (t-test)

The partial regression analysis (t-test) was conducted to determine whether the Deep Learning model individually contributed significantly to children's cognitive development. This analysis evaluates the statistical significance of the regression coefficient associated with the independent variable.

Table 5. Results of the Partial Regression Analysis (t-test)

Variable	B	t	Sig.	Decision
Deep Learning Model	Positive	1.311	0.203	H_0 Accepted

As presented in Table 5, the calculated t-value for the Deep Learning model was 1.311**,** with a significance value of 0.203. Since the obtained significance value exceeded the significance criterion of 0.05, the null hypothesis (H_0) was accepted. Therefore, the Deep Learning model did not have a statistically significant effect on children's cognitive development within the sample of this study.

Although the regression coefficient indicated a positive relationship between the variables, the magnitude of the effect was insufficient to demonstrate statistical significance. This finding implies that improvements in children's cognitive development observed during the study cannot be attributed exclusively to the implementation of the Deep Learning model. Other educational, environmental, and individual factors may have played a greater role in influencing children's cognitive performance. Accordingly, the regression analysis suggests that the Deep Learning model, as implemented in this study, did not serve as a significant predictor of cognitive development among children aged 4–6 years at Cemara Liliba Kindergarten.

6. Descriptive Statistics of Deep Learning Dimensions

In addition to inferential statistical analysis, descriptive statistics were also calculated to examine the implementation quality of the Deep Learning model based on its three main dimensions: Mindful Learning**,** Meaningful Learning, and Joyful Learning. These dimensions represent the core principles of the Deep Learning approach applied in classroom activities at Cemara Liliba Kindergarten. The purpose of this analysis is to identify which dimension is most dominantly implemented and how consistently each dimension is applied during the learning process.

Table 6. Descriptive Statistics of Deep Learning Dimensions

Dimension	N	Minimum	Maximum	Mean	Std. Deviation
Mindful Learning	20	13	20	15.90	1.861
Meaningful Learning	20	14	20	16.30	1.689
Joyful Learning	20	13	20	15.65	1.599

Based on Table 6, all three dimensions of the Deep Learning model demonstrate relatively high mean scores, indicating that the model was implemented effectively in classroom activities. Among the three dimensions, Meaningful Learning obtained the highest mean score **(**M = 16.30**),** followed by Mindful Learning **(**M = 15.90**)** and Joyful Learning (M = 15.65). These results suggest that the learning activities at Cemara Liliba Kindergarten were most effective in helping children connect new learning experiences with prior knowledge and real-life situations.

The standard deviation values for all dimensions are relatively low, ranging from 1.599 to 1.861, indicating that the responses among children were fairly consistent. This means that there was no extreme variation in children's engagement levels across the three dimensions of the Deep Learning model. Overall, the descriptive results show that the implementation of the Deep Learning approach was well executed in terms of learning design and classroom practice.

Despite the relatively high implementation scores across all dimensions, these descriptive findings should be interpreted alongside inferential statistical results. Although children demonstrated positive engagement in Mindful, Meaningful, and Joyful Learning activities, the regression analysis previously presented indicates that these implementation dimensions did not translate into a statistically significant effect on cognitive development outcomes in this study.

DISSCUSSION

The findings of this study indicate that the implementation of the Deep Learning model at Cemara Liliba Kindergarten was generally at a moderate-to-high level based on descriptive statistics. However, the inferential statistical results show that the model did not have a statistically significant effect on the cognitive development of children aged 4–6 years. This section discusses the findings in relation to previous studies and relevant theoretical frameworks to provide a deeper explanation of the results.

First, the descriptive results of the Deep Learning implementation (Table 1) show that most children were in the moderate category (55%), followed by high (30%) and low (15%). This suggests that children were generally engaged in learning activities designed using Deep Learning principles. Similar findings were reported by Andriyani and Pertiwi (2023), who found that structured play-based learning activities can increase children's engagement levels in classroom participation. Likewise, Iskandar and Rahmatullah (2024) emphasized that circuit-based learning models can create active learning environments that support children's participation. These studies support the idea that play-based learning models tend to be well accepted by early childhood learners.

Second, the cognitive development results (Table 2) show that most children were in the moderate category (45%), followed by high (35%) and low (20%). This aligns with the findings of Hidayati et al. (2023), who reported that early childhood cognitive development tends to vary due to differences in environmental stimulation and learning support. Similarly, Angraini and Kusumawardani (2022) found that cognitive development in early childhood is strongly influenced by external factors such as family involvement and learning experiences at school. Therefore, the variation observed in this study reflects the natural diversity in early childhood development stages.

Third, the regression analysis results (Table 3 and Table 5) indicate that the Deep Learning model did not significantly affect cognitive development ($p = 0.203 > 0.05$). This finding is consistent with Fauziyah and Rohyani (2023), who reported that conventional or partially implemented innovative learning models do not always produce significant cognitive outcomes when not supported by consistent instructional strategies. Similarly, Zulkifli and Rahmah (2021) found that structured play activities may improve motor and cognitive skills, but the effect becomes significant only when implementation is intensive and continuous. In this study, the limited duration of implementation and small sample size may have contributed to the non-significant results.

Fourth, the low explanatory power of the model ($R^2 = 0.088$) suggests that most variations in cognitive development were influenced by other factors. This is supported by Rahayu and Sudirman (2022), who emphasized the role of social interaction and scaffolding in cognitive development based on Vygotsky's theory. In addition, Safitri and Wahyono (2023) highlighted that cognitive development in children aged 4–6 years is also influenced by developmental readiness during the preoperational stage, meaning that not all children respond similarly to instructional interventions. Therefore, external and internal developmental factors likely played a stronger role than the learning model itself.

Fifth, despite the lack of significant statistical effect, the descriptive results of Deep Learning dimensions (Table 6) show high mean scores across Mindful, Meaningful, and Joyful Learning. This is consistent with Wulandari and Santoso (2025), who stated that active and enjoyable learning environments enhance engagement but do not always directly translate into measurable cognitive gains. Similarly, Ramadhani et al. (2024) found that play-based learning improves exploratory behavior and motivation, but cognitive outcomes depend on repeated exposure and reinforcement.

Sixth, the highest mean score was found in Meaningful Learning ($M = 16.30$), indicating that children were able to connect learning materials with real-life experiences. This is supported by Nurhayati and Yulianti (2024), who found that manipulatives and contextual learning materials enhance conceptual understanding in early childhood education. However, conceptual understanding alone may not be sufficient to produce statistically significant improvements in cognitive test scores within a short intervention period.

Seventh, Mindful Learning and Joyful Learning also showed relatively strong scores, indicating that children were actively engaged and emotionally positive during learning activities. According to Mulyani and Fitriani (2022), structured play activities enhance attention and focus in early childhood learning. Meanwhile, Wahidah et al. (2023) emphasized that joyful learning environments increase motivation and participation but require sustained implementation to influence cognitive development outcomes significantly.

Eighth, overall findings suggest that although the Deep Learning model was well implemented in terms of learning process quality, it did not produce a significant measurable impact on cognitive development in this study. This may be attributed to the short implementation period, limited sample size, and the influence of uncontrolled external variables such as home learning environment and individual developmental differences.

In conclusion, the results of this study highlight the importance of not only implementing innovative learning models but also ensuring consistency, duration, and environmental support to achieve measurable cognitive development outcomes in early childhood education.

CONCLUSION

Main Findings: This study found that the implementation of the Deep Learning model provided mindful, meaningful, and joyful learning experiences that encouraged children's active participation in classroom activities. However, the regression analysis indicated that the relationship between the Deep Learning model and the cognitive development of children aged 4–6 years at Cemara Liliba Kindergarten was not statistically significant ($p > 0.05$). The coefficient of determination ($R^2 = 0.088$) showed that the model explained 8.8% of the variance in children's cognitive development. **Research**

Contribution: This study contributes empirical evidence on the implementation of the Deep Learning model in an authentic early childhood classroom using an ex post facto research design and highlights that cognitive development is influenced by multiple factors beyond the learning model. **Theoretical and Practical Implications:** The findings reinforce the importance of creating mindful, meaningful, and joyful learning environments while encouraging teachers to integrate the Deep Learning model with other child-centered instructional strategies to better support cognitive development. **Research Limitations:** This study involved only 20 children from one kindergarten and examined a single independent variable, limiting the generalizability of the findings. **Future Research Directions:** Future studies should include larger and more diverse samples and examine additional variables, such as parental involvement, teacher competence, classroom environment, and learning motivation, to provide a more comprehensive explanation of children's cognitive development.

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