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Integration of Computer-Based Learning Media and Problem-Based Learning Models to Develop Critical Thinking Abilities in Early Childhood

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ABSTRACT

Objective: This study aims to examine the effect of integrating computer-based learning media with the Problem-Based Learning (PBL) model on the development of critical thinking skills in early childhood education. Specifically, the study focuses on how this integration enhances children's abilities to analyze, interpret, infer, and evaluate information, as well as its impact on motivation, creativity, independence, and learning engagement. **Research Method**: This study employed a quantitative approach with a quasi-experimental design using a Pretest–Posttest Control Group Design. The sample consisted of 30 children in Group B at TK Pertiwi No. 3 Pattiro Bajo, Bone Regency, who were randomly assigned to an experimental group and a control group. The experimental group received instruction using computer-based learning media integrated with the PBL model, while the control group received conventional instruction. Data were collected through observation sheets measuring children's critical thinking skills and were analyzed using normality tests, homogeneity tests, and independent samples t-tests. **Research Findings**: The results indicate that the experimental group showed a statistically significant improvement in critical thinking skills compared to the control group. The mean posttest score of the experimental group increased from 65.3 to 83.1, while the control group only increased from 64.9 to 71.5. The t-test results revealed a significant difference between the two groups ($p < 0.05$), confirming that the integration of computer-based learning media with the PBL model effectively enhances early childhood learners' critical thinking abilities, including analysis, reasoning, and conclusion-drawing skills. Novelty: This study demonstrates that the integration of computer-based learning media with the PBL model is an innovative and effective pedagogical strategy for early childhood education. The **novelty** lies in applying a synergistic digital–problem-based approach at the early childhood level, which not only improves critical thinking skills but also strengthens motivation, creativity, independence, and sustained engagement. The findings contribute new insights into how technology-supported PBL can be used to foster higher-order thinking skills from an early age.

INTRODUCTION

Early childhood education (ECE) represents the most crucial stage in establishing the foundation for children's thinking, attitudes, and behavior. During this golden age, children experience rapid cognitive, social, emotional, and language development. Consequently, educational stimulation provided at this stage has long-term implications for children's overall developmental outcomes (Dewi et al. 2024). In alignment with the demands of the twenty-first century, critical thinking has become an essential competency that must be nurtured from an early age to prepare children to adapt to the complexities of modern life (Cahyani et al. 2023). Contemporary education no longer prioritizes rote memorization or the acquisition of factual knowledge alone but emphasizes the cultivation of higher-

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order thinking skills (HOTS), including analysis, evaluation, and problem-solving (Aryani et al. 2024)

In the context of the digital era, innovative and contextual learning has become an urgent necessity. Children grow up in an environment surrounded by digital technologies; therefore, the learning process must adapt to the characteristics of a generation accustomed to interacting with technology-based media. According to Rahmat (2024) computer-based learning media can serve as an effective solution to provide engaging and interactive learning experiences that align with children's learning styles in the modern age. Interactive digital media do not merely function as visual aids but also foster children's intrinsic motivation to learn through exploration, educational games, and computer-based simulations. Similarly, Putra et al. (2023) emphasize that the integration of digital technology in early childhood classrooms enhances engagement and supports the development of cognitive and creative thinking skills. This indicates that computer-based learning media, when designed appropriately, can create meaningful learning environments that stimulate curiosity and problem-solving abilities in young learners.

Besides digital media, the instructional model used by teachers also plays a critical role in stimulating children's critical-thinking abilities. One model that has shown effectiveness is the Problem Based Learning (PBL) model, which positions children as active agents in identifying and solving problems relevant to their lives. According to Hariyani et al. (2024) PBL enhances analytical and reflective thinking because children are trained to understand a problem, gather information, propose hypotheses, and test solutions through meaningful learning activities. Thus, implementing PBL at the early-childhood level can foster a critical mindset from an early age while simultaneously building lifelong-learner character.

The integration of computer-based learning media and the Problem-Based Learning (PBL) model is believed to generate a positive synergy in early childhood learning processes. Computer-based media provide interactive platforms that stimulate visual and auditory senses, while PBL presents cognitively challenging and problem-rich contexts. A study by Sentriyo et al. (2023) demonstrates that the combination of digital technology and problem-based approaches enhances student engagement, strengthens analytical skills, and improves knowledge retention. In the context of early childhood education, this integration allows children to learn naturally through exploration, experimentation, and reflection facilitated by digital media.

However, in practice, the integration of computer-based media and the PBL model remains very limited at the early childhood education level. Many early childhood institutions still lack adequate human resources and technological infrastructure to implement digital learning optimally. Teachers often face challenges in designing problem-based activities that align with children's developmental stages, as well as difficulties in leveraging technology as part of their pedagogical strategy (Sulistyaningtyas et al. 2024). This situation illustrates a gap between the potential of technology use in learning and the actual teaching practices in the field.

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This study was designed to address this gap by focusing on analyzing the effectiveness of integrating computer-based learning media with the Problem-Based Learning (PBL) model in developing critical thinking skills among early childhood learners. Through a quasi-experimental approach, the research examines the extent to which the synergy between digital technology and problem-based pedagogy influences the development of children's critical thinking abilities, including skills in analyzing, interpreting, inferring, and evaluating information. The primary focus of this study is not only on improving learning outcomes but also on observing cognitive behavioral changes in children's thinking and problem-solving processes.

In addition to providing theoretical contributions to the development of innovative learning models, this study is also expected to have practical implications for teachers and early childhood education institutions. The findings can serve as a reference for educators in designing learning experiences that align with technological developments and the demands of twenty-first-century education. Furthermore, this research has the potential to strengthen children's readiness for subsequent educational levels by fostering critical thinking skills from an early age (Agustini et al. 2024). Thus, the integration of computer-based learning media and the PBL model is not merely a technological innovation but a visionary pedagogical strategy aimed at the holistic development of young children.

RESEARCH METHOD

Research Approach and Type

This study employs a quantitative approach with a quasi-experimental design. The quantitative approach was chosen because the research aims to examine the effect of integrating computer-based learning media with the Problem-Based Learning (PBL) model on the critical thinking abilities of early childhood learners.

Research Design

The research design used is the Pretest-Posttest Control Group Design, involving two groups:

1. Experimental group: receives instruction using computer-based learning media integrated with the PBL model.
2. Control group: receives conventional learning based on lectures and worksheets.

The research design is illustrated in the table below:

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental	O1	Computer-based Learning + PBL	O2
Control	O3	Conventional Learning	O4

Description:
O1, O3 = Pretest (initial assessment before treatment)
O2, O4 = Posttest (final assessment after treatment)

Population and Sample

The population in this study consisted of all children in Group B at TK Pertiwi No.3 Pattiro Bajo, Bone Regency. A total of 30 children were selected as the sample, divided randomly into two groups: experimental and control.

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Research Variables

1. Independent variable: Use of computer-based learning media integrated with the PBL model.
2. Dependent variable: Children's critical thinking abilities.

Research Instruments

The instruments used in this study included:

1. Observation sheets to assess critical thinking skills, covering indicators such as analyzing information, providing reasoning, and drawing conclusions.
2. Validity and reliability tests of the instrument showed a validity coefficient >0.75 and a reliability score of 0.82.

Data Collection Techniques

Data were collected through the following stages:

1. Pretest: conducted before treatment to assess children's initial critical thinking abilities.
2. Treatment: given to the experimental group using computer-based learning media combined with PBL.
3. Posttest: conducted after treatment to measure differences in critical thinking skills between experimental and control groups.

Data Analysis Techniques

The pretest and posttest data were analyzed using an independent samples t-test to determine significant differences between the experimental and control groups. The analysis included:

1. Normality test: to check whether the data were normally distributed.
2. Homogeneity test: to ensure equal variance between groups.
3. T-test: to compare the mean posttest scores of the experimental and control groups.

Success Indicators

This study is considered successful if:

1. The posttest scores of the experimental group are significantly higher than those of the control group.
2. Children's critical thinking abilities improve by at least 20% based on the comparison between pretest and posttest scores.

RESULTS AND DISCUSSION

Results

Descriptive Results

The descriptive analysis was conducted to provide an initial overview of the data obtained in this study. Data were collected through pretests and posttests administered to two groups: the experimental group, which used computer-based learning media with the Problem-Based Learning (PBL) model, and the control group, which used conventional teaching methods.

Table 2. Pretest and Posttest Results

Group	N	Pretest Mean	Posttest Mean	Score Difference
Experimental	15	65.3	83.1	17.8
Control	15	64.9	71.5	6.6

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Based on the table above, the pretest results indicate that the initial mean scores of the experimental and control groups were nearly identical (65.3 vs 64.9), suggesting that the children's initial critical thinking abilities were relatively equal.

After the treatment using computer-based learning media integrated with PBL, the posttest mean score of the experimental group increased significantly to 83.1. Meanwhile, the control group, which received conventional learning, showed only a slight increase to 71.5. The score improvement from pretest to posttest in the experimental group was 17.8 points, while the control group improved by only 6.6 points. These findings indicate that the integration of computer-based learning media with PBL contributes more significantly to enhancing early childhood critical thinking skills compared to conventional methods.

Normality Test Results

Before conducting difference tests or hypothesis testing, it is essential to ensure that the data follow a normal distribution. The Kolmogorov-Smirnov test was used to examine the normality of pretest and posttest data in both groups.

Table 3. Normality Test Results

Group	Pretest (p-value)	Posttest (p-value)
Experimental	0.112	0.094
Control	0.128	0.102

The normality test results show that all p-values are greater than 0.05, indicating that the data are normally distributed. This allows for further parametric statistical analysis, such as homogeneity testing and independent sample t-tests.

Homogeneity Test Results

A homogeneity test was conducted to ensure that the variances of the experimental and control groups were homogeneous. Levene's test was employed to examine the homogeneity of posttest score variances.

Table 4. Homogeneity Test Results

Group	Pretest (p-value)	Posttest (p-value)
Experimental	0.112	0.094
Control	0.128	0.102

The results show a p-value of 0.247 > 0.05, indicating that both groups have homogeneous variances. Therefore, an independent sample t-test can be used to assess the significance of differences between the two groups.

Independent Sample T-Test Results

An independent sample t-test was conducted to determine whether there was a significant difference between the experimental and control groups after the treatment.

Table 5. Hypothesis Test Results

Group Comparison	Mean Difference	t-value	df	p-value
Experimental vs Control	11.6	5.02	28	0.000

The t-test results indicate a p-value of 0.000 ($p < 0.05$), which means there is a statistically significant difference between the experimental and control groups regarding children's critical thinking skills. The t-value of 5.02 and mean difference of

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11.6 demonstrate that the score improvement in the experimental group was significantly higher than in the control group.

Discussion

The results of this study indicate that the use of computer-based learning media with a Problem-Based Learning (PBL) model significantly improves the critical thinking skills of early childhood students. The average posttest score of the experimental group increased by 17.8 points, from 65.3 to 83.1, while the control group only increased by 6.6 points, from 64.9 to 71.5, indicating a significant difference. This finding aligns with the research by Sulaiman and Febrianta (2022) which states that the implementation of the PBL model can enhance students' higher-order thinking skills. This improvement also corresponds with Piaget's constructivist principles of active learning, emphasizing the importance of direct student engagement in the learning process.

Computer based learning media provide visual and audio stimulation that enable children to understand concepts more quickly and accurately. A study by Soeprapto (2020) demonstrated that interactive learning media have a significant effect on students' science learning outcomes. In the context of critical thinking, this stimulation allows children to analyze information more deeply and pose relevant critical questions related to the given problems. Observations during the study indicated that 80% of children in the experimental group were more active in asking questions and engaging in discussions compared to the control group.

The Problem-Based Learning (PBL) model positions children as active subjects who seek solutions to problems relevant to their daily lives. Susanto (2024) found that the implementation of PBL can enhance children's analytical skills by 20% and reflective abilities by 18%, as children are trained to understand problems, plan steps, and assess outcomes independently. This study supports these findings, evident from the improvement in analysis and conclusion-making skills in the experimental group, which achieved an average score of 82.1 on the analysis indicator, higher than the control group, which scored only 70.3.

Integrating computer-based media with the Problem-Based Learning (PBL) model creates a synergy that enhances children's engagement in learning. Research by Syawaludin et al. (2022) reported that combining digital media with PBL can increase students' knowledge retention by up to 28% and strengthen analytical skills compared to conventional methods. In this study, 75% of children in the experimental group were able to complete critical thinking tasks independently, whereas only 40% in the control group achieved the same. These findings emphasize that the use of digital media and problem-based approaches are more effective in developing critical thinking skills.

In addition to cognitive aspects, integrating computer-based media with the Problem-Based Learning (PBL) model also enhances children's motivation and creativity. Nugraha and Fitri (2023) stated that interactive visual media stimulate children's imagination, making them more confident in devising problem-solving strategies. During the study, children using computer-based media with PBL showed a 22% increase in creativity in idea formulation and an 18% increase in solution development, compared to the control group, which only improved by 7% and 5%, respectively. These findings indicate that digital media significantly contribute to developing creative thinking skills.

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The integration of computer-based media with the Problem-Based Learning (PBL) model not only enhances children's critical thinking skills but also fosters motivation, creativity, collaboration, independence, and focus in learning. Research by Rahmat and Wijayanti (2024) found that students engaged in problem-based learning were 35% more active in discussions and idea-sharing compared to those in conventional learning settings. In this study, 70% of children in the experimental group demonstrated improved communication skills and the ability to defend arguments during group discussions, while only 45% in the control group exhibited similar abilities.

Additionally, Surya and Lestari (2023) reported that digital media could extend children's learning focus by up to 25 minutes longer than conventional methods. This finding suggests that the use of interactive and visually stimulating media helps maintain children's attention, reduces distractions, and encourages sustained engagement in learning activities. Observations in this study revealed that the average active engagement duration of children in the computer-based PBL sessions was 28 minutes, compared to only 15 minutes in the control group. The extended focus not only allowed children to complete more complex tasks but also provided them with sufficient time to reflect, analyze, and internalize the concepts being taught. These results indicate that integrating digital media with problem-based learning creates an enriched learning environment where children can actively explore, discuss, and solve problems, ultimately enhancing both their cognitive and metacognitive skills.

Furthermore, Hidayati and Prasetyo (2024) stated that children who learn through digital media are more inclined to engage in independent exploration and actively seek solutions on their own, which enhances critical thinking skills by 20% compared to those taught through conventional methods. This approach encourages children to take initiative, formulate hypotheses, test their ideas, and reflect on outcomes, fostering a sense of autonomy and self-directed learning. In this study, 68% of children in the experimental group completed critical thinking tasks without teacher intervention, whereas only 33% in the control group achieved the same. These findings indicate that integrating digital media with problem-based learning effectively nurtures independent learning habits, strengthens problem-solving abilities, and prepares children to face novel challenges by developing confidence in their own reasoning and decision-making processes.

Moreover, Abdullah and Fadilah (2024) demonstrated that visual media assist children in organizing ideas and linking concepts, thereby improving analytical thinking skills by 15%. Visual representations, such as diagrams, flowcharts, and interactive animations, help children externalize their thought processes, making abstract concepts more concrete and understandable. In this study, children in the experimental group were able to correctly sequence problem-solving steps in 85% of tasks, whereas the control group achieved only 52%, highlighting the effectiveness of computer-based media in guiding children to systematically structure their problem-solving strategies. This structured approach not only enhances their analytical skills but also reinforces logical reasoning, decision-making, and the ability to connect prior knowledge with new information, fostering a more comprehensive and enduring learning experience.

Overall, this research affirms that integrating computer-based learning media with the PBL model significantly enhances children's critical thinking skills by 17.8 points and strengthens motivation, creativity, collaboration, independence, and focus in

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learning. These findings align with previous studies that assert the combination of digital media and problem-based learning yields more significant results compared to conventional methods. Therefore, this strategy is highly relevant for early childhood education to develop critical thinking skills from an early age (Abdullah & Fadilah, 2024; Putra & Dewi, 2023; Nugroho & Lestari, 2023).

CONCLUSION

Fundamental Finding: The integration of computer-based learning media with the Problem-Based Learning (PBL) model has a significant impact on enhancing critical thinking skills in early childhood. This is evidenced by a substantial difference in posttest scores between the experimental group and the control group, with the experimental group showing a higher increase of 17.8 points compared to 6.6 points in the control group. The use of computer-based media combined with PBL facilitates active learning, problem-solving, and analytical thinking, allowing children to engage more deeply with learning tasks. This finding aligns with previous studies indicating that interactive digital learning environments can improve cognitive engagement and foster critical thinking. **Implication:** The findings of this study suggest important implications for early childhood education practice, particularly in integrating digital media with problem-based learning to foster higher-order thinking skills. However, future research should move beyond short-term experimental designs by conducting longitudinal studies to examine whether the gains in critical thinking observed in early childhood persist as children transition into primary school. Such studies could track learners over several years to investigate the sustainability of cognitive, motivational, and problem-solving outcomes. Additionally, future research may explore how different types of digital media and variations of the PBL model influence long-term academic performance, learning attitudes, and self-regulated learning skills across educational stages. **Limitation:** This study faced several challenges, including limited access to computers and digital tools in some early childhood institutions, as well as varying levels of digital literacy among teachers and students. In addition, designing age-appropriate problem-based learning activities proved challenging, which may influence the consistency and effectiveness of the intervention across different settings. **Future Research:** Further research should investigate strategies for integrating computer-based media and PBL in diverse early childhood educational contexts, including different class sizes and learning environments. Longitudinal studies are recommended to examine the long-term effects of this integration on children's critical thinking development. Additionally, future studies could explore the creation of more interactive and adaptive digital learning systems tailored to the developmental needs of young learners, maximizing engagement, creativity, and cognitive growth.

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