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The Influence of the Inquiry Project-Based Learning Model on Critical Thinking Skills in Early Childhood: A Quantitative Experimental Study

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Keywords:

Inquiry Project-Based Learning, Critical Thinking Skills, Early Childhood Education, Experimental Method, Quantitative Analysis.

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Received 12 08 2023
Revised 25 09 2023
Accepted 26 09 2023
Published Online First
30 09 2023



Abstract

This study aims to measure the impact of the Inquiry Project-Based Learning model on the critical thinking abilities of children aged 5-6 years at Budya Wacana Kindergarten, Yogyakarta. The research methodology adopted an experimental quantitative approach with a pre-experimental design, specifically the one-group pretest-posttest design. The sample consisted of 35 children selected through the Total Sampling technique. Data were collected using observation sheets and documentation, with instruments focusing on five indicators of critical thinking ability. Data analysis employed normality tests, homogeneity tests, and paired sample t-tests using SPSS 25. The results indicated a significant increase in posttest essential scores of thinking (86.03) compared to the pretest (47.60), with a t-value of -31.352 and a significance of 0.000. These findings affirm the effectiveness of this learning model in enhancing early childhood critical thinking skills while also opening opportunities for further research in early childhood education. This study has significant implications for educational practice, suggesting integrating the Inquiry Project-Based Learning method into the curriculum and highlighting the need for teacher training to implement this method. However, limitations exist, such as focusing on a limited sample size and not evaluating long-term effects.

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To cite: Yuliani, R., Jabar, C. S. A., & Maryatun, I. B. (2023). The influence of the inquiry project-based learning model on critical thinking skills in early childhood: A quantitative experimental study. *Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini*, 8(3), 193-202. <https://doi.org/10.14421/jga.2023.83-08>

Introduction

In the realm of early childhood education, the development of critical thinking skills is paramount for future academic and life success. This subject is significant in education and a crucial issue affecting global society. The foundation of these skills, particularly in children aged 5-6 years, is a matter of increasing interest and concern. The ability to foster critical thinking at an early age presents both a challenge and an opportunity for educational systems worldwide. Adopting innovative educational models, such as inquiry project-based learning, is emerging as a promising solution to this pressing academic problem (Johnson et al., 2019; Probine et al., 2023).

The Inquiry Learning model is an educational approach that aims to instill the foundations of scientific thinking and develop creativity and problem-solving skills in students. As described by Sagala (2011), students are positioned as active learning subjects in this process, leading to a learning environment where they engage in more self-directed learning. Essentially, inquiry learning activates students to think scientifically (Wartono et al. (2018), encouraging them to ask questions actively and experiment independently throughout the learning process. This approach results in meaningful, enduring learning outcomes that are not easily forgotten due to the emphasis on self-discovery and investigation.

Project-Based Learning (PjBL), as outlined by Chu et al. (2021), is a pedagogical method that employs real projects as the foundation of student learning. PjBL emphasizes tasks or

projects that prompt students to seek information, identify problems, solve them, and present their work as a product or service (Jonassen & Hung, 2012). According to Serevina et al., (2022) PjBL is a learning method that allows students to engage in actual tasks or projects, focusing on applying knowledge in real-life contexts. It involves students in problem-solving or product creation, emphasizing developing critical, creative, and collaborative skills necessary for real-world success. Savery, (2015) notes that PjBL aims to enhance students' skills and understanding by providing more integrated and meaningful learning experiences. Through PjBL, students become more actively involved in their learning and gain independence in problem-solving (Solihin et al., 2022).

Numerous studies have emphasized the role of inquiry-based learning in enhancing critical thinking and problem-solving skills in young learners. For instance, Cherniak et al., (2019) highlighted the success of combining robotics education with an inquiry-based approach in engaging children in STEM subjects. Similarly, Rish and Cun (2018) observed that secondary education students exhibit increased agency and creativity in inquiry projects. These findings underscore the potential of inquiry-based methods in fostering critical thinking skills in children.

Learning through play has also been explored extensively in recent literature. Parker et al., (2022) propose an expanded definition of this concept in schools to promote holistic skill development, addressing the gap between education policy and practice. Additionally, Hooker, (2019) discussed the benefits of ePortfolios in early childhood education, emphasizing their role in enhancing children's involvement in formative assessment. This body of work suggests that playful and interactive approaches can significantly contribute to developing critical thinking skills in young children.

However, despite these promising approaches, several studies have identified gaps in implementing critical thinking skills in early childhood education. Johnston and Bull, (2021) pointed out a way to improve the connection between early childhood educators' recognition of the importance of mathematics and its actual implementation in teaching practices. Hayes and Rooney (2019) also emphasized improving educators' communication skills to enhance child-led interactions. These studies highlight a discrepancy between theoretical understanding and practical application in early childhood education settings.

Further, recent research has identified limitations and controversies in the current pedagogical frameworks. Walsh et al., (2019) revealed differences in teachers' approaches to play-based education, suggesting a need for a more balanced pedagogical framework. Similarly, Ortega-Sánchez and Jiménez-Eguizábal (2019) found that integrating project-based learning with technology significantly enhances competencies in infant-education teacher trainees, indicating a gap in technological integration in current pedagogies.

This study aims to address these gaps by investigating the impact of the inquiry project-based learning model on the critical thinking abilities of children aged 5-6 years in TK Budya Wacana, Kota Yogyakarta. The research measures how much this educational model influences vital thinking skills. By situating the study within existing literature and highlighting the disparities in current practices, this research intends to contribute meaningful insights into the effectiveness of inquiry project-based learning in early childhood education.

The primary objective of this study is to empirically evaluate the influence of the inquiry project-based learning model on enhancing critical thinking skills among young children. This research aims to provide empirical evidence to support or refute the effectiveness of this educational approach. By doing so, it seeks to contribute to the body of knowledge in early childhood education and offer practical implications for educators and policymakers in implementing innovative teaching methodologies that foster critical thinking skills in young learners.

Methods

This study adopts a quantitative approach with an experimental method, utilizing a pre-experimental design. Specifically, it implements a one-group pretest-posttest procedure

(Atoneche & Kastberg, 2017; Dyevre & Ovádek, 2020), wherein a single experimental group undergoes pre-and post-tests. The primary aim of this research is to explore the impact of the Inquiry Project Learning model on the critical thinking abilities of early childhood.

The research steps include formulating objectives, determining the design, selecting sampling techniques, data collection methods, and data analysis techniques. The study sample comprises 35 children aged 5-6 years from Budya Wacana Kindergarten, Yogyakarta, selected through the Total Sampling technique (Kay & Worth, 2001). This process ensures full population representation, reducing sampling errors. Below is the table for the one-group pretest-posttest design used in this study:

Table 1. One Group Pretest - Posttest Design

PreTest	Treatment	PostTest
O1	X	O2

Explanation:

O1 = Pretest score before treatment;

X = Treatment using the Inquiry Project Based Learning model;

O3 = Posttest score after treatment.

For data collection, the study used observation sheets and documentation. Observations were conducted twice: before and after the treatment. The pretest and posttest measurement tools were questionnaires filled out by the classroom teachers. The treatment in this study was implementing the inquiry project-based Learning model. Data analysis was performed using tests of normality, homogeneity, and hypothesis testing with SPSS software version 25.

The research instrument focused on five indicators of early childhood critical thinking abilities: Asking Questions, Point of View, Being Rational, Finding Out, and Analyzing, using guidelines from various related literature (Changwong et al., 2018; Ennis, 2011; Jacob & Sam, 2008; Putra et al., 2018). Each indicator is detailed in the instrument grid outlined in Table 2.

Table 2. Instrument Grid for Critical Thinking Ability of Children Aged 5-6 Years

Variable	Sub Variable	Indicator	Descriptor
Critical Thinking	Asking Question	Actively engaged in the learning process by asking many questions	After using the Inquiry Project Based Learning model, the child shows a habit of asking in-depth questions (5W+1H)
		Identifying problems or difficulties in everyday situations	After using the Inquiry Project Based Learning model, the child can recognize situations when asking questions
	Point of View	Forming own opinions and thoughts	After using the inquiry project-based Learning model, the child can express their opinions on a subject.
	Being Rational	Providing accurate and logical evidence for opinions and thoughts	After using the Inquiry Project Based Learning model, the child can accept ideas and suggestions from peers
	Finding Out	Seeking simple to complex facts from various sources (parents, books, environment, media)	After using the inquiry project-based Learning model, the child can explain the difference between right and wrong opinions.
Explaining the role and function of different information sources, like books, the internet, or peers, and their advantages and disadvantages		The child can critique incorrect opinions after using the inquiry project-based Learning model.	

Analysis	Concluding results	After using the inquiry project-based Learning model, the child can summarize learning outcomes.
	Arguing with supporting evidence	The child can argue with supporting evidence after using the inquiry project-based Learning model.

The validity of the research instrument was confirmed through instrument analysis by Dr. Ika Budi Maryatun, M.Pd, an expert in Early Childhood Education (Nizary & Nur Kholik, 2021). This included an evaluation of the instrument's content alignment with the curriculum or teaching plan implementation to ensure the instrument's suitability for the context of early childhood education.

Result

3.1. Data Analysis Description

The pretest was conducted over two consecutive days by observing regular classroom learning using the discovery learning model. Participants were taught using the inquiry project-based learning model for three days, followed by post-test results. The outcomes analyzed using SPSS 25 and presented in the descriptive analysis table below are as follows:

Table 3. Descriptive Statistical Analysis of Pretest and Posttest

	N	Minimum	Maximum	Mean	Std. Deviation
PreTest	35	34	59	47.60	7.578
PostTest	35	63	100	86.03	8.631
Valid N (listwise)	35				

According to the descriptive analysis results, the number of data (N) for both pretest and posttest is 35 children. The average pretest score is 47.60, while the average posttest score is 86.03. These results indicate an increase in the pretest score by 7.578 and the posttest score by 8.631. Next, the normality of the pretest and posttest data was assessed using SPSS 25.

3.2. Normality Test

The descriptive analysis found that the inquiry project-based learning model impacts children's critical thinking ability. The normality test was then conducted to determine if the data distribution was standard and a prerequisite for proceeding with hypothesis testing. The results are presented below:

Table 4. Normality Test of Pretest and Posttest

	Kolmogorov-Smirnov^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
PreTest	.110	35	.200*	.944	35	.076
PosTest	.135	35	.104	.951	35	.118

The normality test calculations yielded significance values for all pretest and posttest data using the Kolmogorov-Smirnov and Shapiro-Wilk tests, with p-values > 0.05. Therefore, this study can conclude that it has data usually distributed.

3.3. Homogeneity Test

The normality analysis indicated a normal distribution. Next, the homogeneity test, a parametric statistical test when data are typically distributed, was conducted to determine if the data are homogeneous, thus proceeding to the next stage of data analysis. The results are shown in Table 5 below:

Table 5. Homogeneity Test of Pretest and Posttest

		Levene Statistic	df1	df2	df3
Results of PreTest and PostTest	Based on Mean	3.039	1	68	.086
	Based on Median	2.829	1	68	0.94
	Based on the Median and with adjusted df	2.892	1	66.082	0.94
	Based on trimmed mean	3.061	1	68	0.85

The homogeneity test calculations resulted in a significance value Based on a Mean of 0.086 > 0.05, indicating homogeneity. Therefore, this study can use parametric statistical hypothesis testing to analyze the data.

3.4. Hypothesis Testing

The homogeneity analysis indicated that the data are suitable for hypothesis testing. This study conducted a paired sample t-test to examine the impact of the inquiry project-based learning model on the critical thinking ability of children aged 5-6 years. The results are presented in Table 6 below:

Table 6. Hypothesis Testing Paired Sample T-Test

		Paired Differences			95% Confidence Interval of the Difference	T	df	Sig. (2- tailed)
		Mean	Std. Deviation	Std. Error Mean				
Pair 1	PreTest- PostTest	-41.371	7.807	1.320	Lower -44.053 Upper -38.690	-31.352	34	.000

This study uses parametric statistics, specifically the paired sample t-test, to analyze children's critical thinking. The analysis yielded a t-value of -31.352 with a significance value of 0.000, less than 0.05. These results indicate that the inquiry project-based learning model significantly affects children's critical thinking ability.

This study reveals essential facts through careful statistical analysis. The paired sample t-test results, with a t-value of -31.352 and a significance of 0.000, well below the threshold of 0.05, strongly affirm that the inquiry project-based learning model significantly impacts enhancing the critical thinking ability of children aged 5-6 years. The decrease in average scores from pretest to posttest by 41.371 points, with a 95% confidence interval ranging from -44.053 to -38.690, indicates a significant and consistent change in the examined sample. These results underscore the importance of innovative learning models in early childhood education.

These findings have substantial implications for early childhood education practice. Firstly, they highlight the importance of integrating inquiry project-based learning methods into the curriculum to facilitate children's cognitive development. Secondly, they reinforce the idea that young children have the capacity for critical thinking, which can be further optimized through appropriate learning approaches. Thirdly, these findings provide empirical evidence supporting a shift from traditional learning methods to more exploratory and student-centered approaches, stimulating children's critical thinking ability.

This study paves the way for further research in this field. First, future research could explore the application of this model to different age groups or in diverse cultural contexts to understand its adaptability and effectiveness more broadly. Second, there is potential to delve deeper into the supporting and inhibiting factors in implementing this model in different educational environments. Third, upcoming research could focus on developing more robust assessment instruments to measure the long-term impact of learning models like this on critical

thinking ability. Thus, this study's results provide current insights and open doors for further exploration in early childhood education.

Discussion

This research focuses on the impact of the inquiry project-based learning model on the critical thinking abilities of early childhood. Employing an experimental quantitative approach, this study addresses a significant question in early childhood education, reflecting previous research in innovative and critical learning (Cherniak et al., 2019; Parker et al., 2022). According to the literature, approaches such as inquiry-based learning have been recognized for enhancing children's engagement in STEM and broadening the definition of learning through play (Farris & Purper, 2021; Rowe, 2017). This research contributes to these insights by measuring the direct impact of a specific learning model on children's cognitive abilities.

The results of this study indicate a significant increase in children's critical thinking abilities, with an average score improvement from the pretest to the post-test of 38.43 points. These findings affirm the effectiveness of the inquiry project-based learning model and provide quantitative solid evidence of its impact on early childhood critical thinking skills. This significant result demonstrates the substantial potential of active and student-centered learning methods in enhancing essential skills at a very young age (Sundararajan et al., 2018; Tiruneh et al., 2018; Ulger, 2018).

Data analysis from the study shows a substantial influence of the inquiry project-based learning model on children's critical thinking, particularly among 5-6-year-olds attending TK Budya Wacana in Yogyakarta. Statistical results support rejecting the null hypothesis (H_0) and accepting the alternative view (H_a). The data indicates that children tended to be more active in asking questions, engaging in discussions, and showing enthusiasm throughout the learning process during the treatment period. This aligns with Ghufroon et al., (2023) view that 21st-century critical thinking skills are vital for students to identify problems and seek appropriate solutions. Recognizing and understanding children's attitudes during the learning process is essential for positively influencing their academic achievements (Özelçi & Çalışkan, 2019). Achieving these educational goals relies heavily on learning as the key to development. Enhancing student thinking abilities can be achieved by developing and using various learning models, methods, materials, open resources, student worksheets, and educational media (Ichsan et al., 2019). This is also supported by (Marissa, 2022), who states that learning is an active process where students learn by developing what they know rather than passively receiving information.

Compared to previous studies, these results are consistent with Cherniak et al., (2019), who found that inquiry-based robotics education enhances children's engagement in STEM. However, this research extends these insights by applying the inquiry project-based learning model to critical thinking abilities. On the other hand, it also challenges the traditional understanding of early childhood capacity for critical thinking, which was previously underexplored in project-based learning (Parker et al., 2022; Rish & Cun, 2018). It demonstrates that young children can engage in complex learning and benefit substantially from it (Krajcik & Shin, 2014).

There are findings indicating low levels of critical thinking among Indonesian children. A study by Irawan et al. (2017) in Padang, West Sumatra, found that most kindergarten children exhibited low essential thinking abilities, with only about 21% of 149 children showing good critical thinking skills. Developing the Inquiry Project Learning model by 'Ulum (2023) has proven effective in enhancing meticulousness, responsibility, and student academic achievement. This model's main characteristics include syntax, social system, reaction principle, support system, instructional impact, and accompanying impact. The development results show

a significant increase in student learning outcomes by 65.8%, a sense of responsibility by 87.1%, and meticulousness by 92.7%. The model is oriented towards the intellectual development of students, and the results show a significant impact on enhancing critical thinking abilities.

Other related research also supports these findings. Cahyaningsih & Harun (2023) found that project-based learning positively and significantly affects critical thinking abilities. Priyanti & Warmansyah (2021) also discovered that inquiry learning enhances early childhood essential thinking abilities. The eight indicators used in this study include active engagement in the learning process, problem identification, opinion formation, logical evidence, seeking facts from various sources, explaining the role of information sources, concluding results, and arguing with supporting evidence. The inquiry project-based learning model creates an open learning system, allowing children to engage in planning, collaboration, questioning, debating, and proposing ideas, all crucial parts of children's learning activities.

These findings illustrate that the inquiry project-based learning model effectively enhances early childhood critical thinking abilities, a critical skill development skill. They affirm the importance of adopting innovative and student-centered learning approaches at the preschool level (Ma et al., 2020). It is important to note that, despite significant changes, the interpretation should be cautious, considering variations in individual children's capacities and educational contexts (Smallhorn et al., 2015). Therefore, further research is required to explore various factors that may affect the effectiveness of this model.

This research also provides new insights into the potential of project-based learning models to facilitate cognitive development at an early age. The results indicate that children not only respond positively to innovative learning methods but also show significant improvements in their critical thinking abilities. However, interpretation needs caution, particularly regarding generalizing results to a broader population and different educational contexts (Trinanda & Yaswinda, 2022).

These findings significantly contribute to early childhood education practices, emphasizing the importance of developing critical thinking skills from an early age. Implications include revising and updating preschool curricula to incorporate more active and student-centered learning methods. This study also suggests the need for more in-depth teacher training regarding implementing innovative learning approaches in the classroom. Additionally, the findings underscore the importance of further research to evaluate the long-term impact of these learning approaches on children's cognitive abilities.

Conclusion

This research, aimed at measuring the impact of the inquiry project-based learning model on the critical thinking abilities of children aged 5-6 years, has yielded significant findings: there is a measurable increase in essential thinking ability, as evidenced by the average post-test score rising to 86.03 from a pretest score of 47.60. The paired sample t-test results show a t-value of -31.352 and a significance value of 0.000. These findings have important implications for early childhood education, underscoring the necessity of integrating the inquiry project-based learning method into the curriculum to facilitate children's cognitive development and support the shift from traditional learning methods to more explorative, student-centered approaches. Although this study provides valuable insights, it has limitations, such as focusing on a limited sample from Budya Wacana Kindergarten, Yogyakarta, and not yet evaluating the long-term effects of the learning model. Therefore, further research with a broader and more diverse sample is recommended, exploring the model's adaptability in different cultural contexts and developing more effective assessment instruments to measure the long-term impact of the learning model on children's cognitive development. Thus, this research contributes to the

current understanding and opens opportunities for further investigation in early childhood education.

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