



The Effect of Mobile Learning on Critical Thinking Skills of Early Childhood Education Teacher Prospective Students: Meta-Analysis 2021-2024

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Abstract

Many previous studies have reported that there are many different impacts of the application of mobile learning in improving students' critical thinking skills. This study aims to determine the effect of mobile learning on critical thinking skills in early childhood teacher candidates through meta-analysis. In this study, 27 studies that met the inclusion criteria were analyzed. The inclusion criteria in this study are 1) the research was published in 2021-2024; 2) the research must be relevant; 3) research must be reputable indexed by SINTA or Scopus; 4) The research must report complete data. The data was analyzed using Excel and JASP applications by presenting the results of effect size, funnel plot, and publication bias. The results of the analysis concluded that mobile learning had a positive influence on the critical thinking ability of prospective early childhood education teachers compared to other learning ($g = 1.204$; 95% CI 1.007; 1.401; $p < 0.001$). (This finding informs that mobile learning is effective in improving the critical thinking skills of prospective early childhood education teachers.

Keywords: *Mobile Learning; Critical Thinking; Early Childhood Learning; Meta-analysis*

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Introduction

Critical thinking skills are one of the abilities that must be possessed by prospective Early Childhood Education teacher candidates to support learning in the 21st century era (Pitorini et al., 2024; Zulkifli et al., 2022; Asnur et al., 2024). This ability involves an analytical, evaluative, and reflective thinking process, which allows individuals to identify, understand, and solve problems rationally. In the context of early childhood education, critical thinking skills are key in designing learning that not only stimulates children's cognitive development, but also builds their ability to face the challenges of the modern world (Patandung, 2023; Kadir, 2020). Students who are prospective early childhood education teachers who have the ability to think critically are able to choose relevant learning strategies, adapt to the individual needs of children, and create an interactive and collaborative learning environment. Thus, the

mastery of this skill not only enriches the pedagogic competence of prospective teachers, but also contributes to the formation of the foundation of children's critical thinking from an early age (Aslan & Aybek, 2024; Pitorini et al., 2024; Dewanto et al., 2023).

In the era of the Industrial Revolution 4.0 and the transition to the Industrial Revolution 5.0, the need for educators who have critical thinking skills is increasing. Prospective early childhood education teachers are not only required to be able to transfer knowledge, but also to become learning facilitators who are able to integrate technology and innovation in the educational process (Setraksa & Namwan, 2024; Sarwi et al., 2024). Critical thinking skills enable them to evaluate information from multiple sources, adopt an evidence-based approach, and make strategic decisions in complex learning situations (Ali et al., 2024). In addition, this ability also helps prospective PAUD teachers in facing global challenges, such as cultural diversity, curriculum changes, and technological advancements (Uluk et al., 2024; Abdullah et al., 2024). Therefore, the provision of critical thinking skills must be the main focus in the education program of prospective teachers, as a strategic step to build a quality education system that is relevant to the needs of the times.

Although critical thinking skills have been recognized as one of the essential competencies for prospective Early Childhood Education teachers, the challenges in the world of education to realize this are still quite significant (Dewanto et al., 2023). One of the main obstacles is the lack of integration of critical thinking skill development in the educational curriculum of early childhood education teachers (Wantu et al., 2024). A curriculum that focuses too much on theoretical aspects and lacks reflective practice often makes it difficult for prospective teachers to develop critical thinking skills in the context of real learning. In addition, limited facilities and resources, such as access to supporting educational technology, are also obstacles in equipping prospective early childhood education teachers with analytical, evaluative, and reflective thinking skills. As a result, many prospective early childhood education teachers are not fully prepared to design learning that is adaptive and relevant to the needs of early childhood development in the 21st century (Zulyusri et al., 2023).

On the other hand, the pressure on higher education institutions to produce work-ready graduates often comes at the expense of the development of critical thinking skills (Lin et al., 2024; Luritawaty et al., 2024). Prospective early childhood education teachers who are faced with administrative demands and rigid academic achievement standards tend to be given less space to explore innovative learning approaches that support reflective skills (Alarfaj, 2023). This challenge is increasingly complex with different levels of awareness and support from educators or lecturers regarding the importance of critical thinking in early childhood education. Therefore, systemic reforms are needed in early childhood education teacher education that not only provide access to technology-based and innovation-based learning methods, but also create an environment that encourages prospective teachers to think critically and reflectively (Peña et al., 2023). In this way, they are not only able to face the dynamics of modern learning but also make a real contribution in building a generation that thinks critically from an early age.

To overcome the challenges in producing prospective early childhood education teachers who are able to think critically and reflectively, the role of digital technology, especially mobile learning, is a relevant strategic solution in the modern era (Erol & Erol, 2023; Silva et al., 2022; White, 2022). Mobile learning offers flexibility and accessibility that allows prospective teachers to learn anytime and anywhere, without space and time limitations. Through the use of mobile-based learning applications, prospective teachers can access materials specifically designed to practice critical thinking skills, such as case study analysis, learning simulations, and interactive discussions (Alan, 2022; Patonah et al., 2021). This technology also allows them to engage in experiential learning, where they can integrate theory and practice directly. In addition, interactive and multimedia features in mobile learning, such as videos, quizzes, and discussion forums, help increase the motivation and

involvement of prospective teachers in the learning process, thereby supporting the development of their reflective skills (Kousloglou et al., 2023).

Mobile learning also provides opportunities for personalized learning, where materials and assignments can be tailored to the individual needs and abilities of prospective teachers (Kiriktaş & Şahin, 2021; Yaniawati et al., 2022). By utilizing this technology, prospective ECCE teachers can not only understand modern pedagogical concepts, but also learn how to apply them critically in real-life situations, including in supporting early childhood development (Yefang et al., 2024; Kadir, 2020). Furthermore, mobile learning can broaden their horizons through access to global learning resources, allowing them to explore innovative approaches from different educational contexts around the world. Thus, mobile learning not only contributes to improving the quality of education of prospective early childhood teachers, but also becomes an effective tool to build critical and reflective thinking skills that are indispensable in supporting early childhood learning that is relevant to the needs of the 21st century (Sutoyo et al., 2023; Pitorini et al., 2024).

Previous research by Crompton and Burke (2018) showed that mobile learning has a positive impact on improving critical thinking skills in students. The study found that interactive features in mobile apps, such as simulations and real-life situation-based quizzes, encourage students to analyze, evaluate, and make decisions independently. Research by Chai et al. (2020) examines the application of mobile learning in teacher education, especially in improving reflective thinking competence. Their results show that the use of this technology can promote experiential learning, where prospective teachers are involved in the learning process that encourages reflection on the practices they have done. Research by Bano et al. (2022) explores how mobile learning can be used to train prospective teachers in designing innovative learning. This study found that mobile learning helps prospective early childhood education teachers in understanding technology-based learning approaches, such as the use of educational applications for children.

Although research on mobile learning and critical thinking skills has been widely conducted, most research tends to focus on its application in general education or specific subjects, such as science and mathematics. Research that specifically examines the effectiveness of mobile learning in improving critical thinking skills in prospective Early Childhood Education teachers is still very limited. In addition, although there are relevant studies, most of them are descriptive and do not provide a thorough analysis of the effectiveness of mobile learning in the context of the education of prospective teachers of early childhood education. Meta-analysis research that systematically integrates the results of previous studies to provide stronger conclusions regarding the influence of mobile learning on critical thinking skills in prospective early childhood education teachers has not been widely conducted. This creates a significant research gap to explore. Based on this, this study aims to determine the influence of mobile learning learning on critical thinking skills in early childhood teacher candidates through meta-analysis.

Methodology

This study uses a meta-analysis approach to determine the effect of mobile learning on critical thinking skills in early childhood teacher candidates. Meta-analysis is a research approach that evaluates previous research statistically to reach a conclusion (Tamur et al., 2020; Badawi et al., 2023; Nurtamam et al., 2023; Zulyusri et al., 2023). The meta-analysis research procedure is 1) determining the research inclusion criteria, 2) collecting data and coding, 3) analyzing the data statistically can be seen Figure 1.

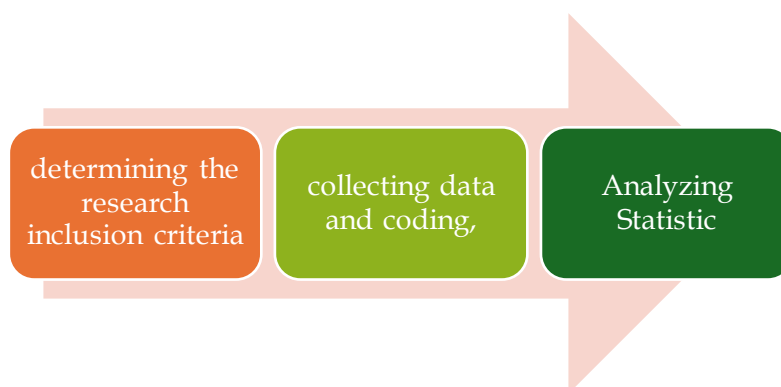


Figure 1. Prosedur Meta-analysis

Eligibility Criteria

In the process of searching for data through the Google Scholar, ScienceDirect, Wiley, ERIC, ProQuest, Frontiers and Web of Science databases, the research must meet several inclusion criteria, namely 1) the research was published in 2021-2024; 2) the research must be relevant; 3) research must be reputable indexed by SINTA or Scopus; 4) The research must report complete data. From the data search, 27 studies were obtained that met the inclusion criteria published in 2021-2024 which can be seen in Table 2.

Statistical Analysis

Data analysis in this study calculates the effect size value of each study analyzed. The effect size value in this study is to calculate the effect of mobile learning on critical thinking skills in early childhood teacher candidates. According to (Borenstein et al., 2007) The stages of data analysis in the meta-analysis can be seen in (Figure 1.). Furthermore, the criteria for the effect size value in the study can be seen in Table 1.

Table 1. Category Effect Size Value

Effect Size	Category
$0.0 \leq ES \leq 0.2$	Low
$0.2 \leq ES \leq 0.8$	Medium
$ES \geq 0.8$	High

Source: (Borenstein et al., 2007; Bachtiar et al., 2023; Tamur et al., 2020)

Result and Discussion

Based on the results of data search through the database, 27 studies/articles met the inclusion criteria. The effect size and error standard can be seen in Table 2.

Based on Table 2, the effect size value of the 27 studies ranged from 0.37 to 2.16. According to Borenstein et al., (2007) Of the 27 effect sizes, 6 studies (22.2 %) had medium criteria effect sizes and 21 studies (77.78%) had high criteria effect size values. Furthermore, 24 studies were analyzed to determine an estimation model to calculate the mean effect size. The analysis of the fixed and random effect model estimation models can be seen in Table 3.

Based on Table 3, a Q value of 143.062 was obtained higher than the value of 7.385 with a coefficient interval of 95% and a p value of $0.001 <$. The findings can be concluded that the value of 24 effect sizes analyzed is heterogeneously distributed. Therefore, the model used to calculate the mean effect size is a random effect model. Furthermore, checking publication bias through funnel plot analysis and Rosenthal fail safe N (FSN) test (Tamura et al., 2020; Badawi et al., 2022; Ichsan et al., 2023b; Borenstein et al., 2007; Asnur et al., 2024). The results of checking publication bias with funnel plot can be seen in Figure 2.

Table 2. Effect Size and Standard Error Every Research

Journal Code	Years	Variable	Standard Error	g
PK 1	2021	Critical Thinking	0.30	1.27
PK 2	2021	Critical Thinking	0.35	0.93
PK 3	2024	Critical Thinking	0.37	1.71
PK 4	2021	Critical Thinking	0.24	0.68
PK 5	2024	Critical Thinking	0.31	2.14
PK 6	2023	Critical Thinking	0.27	1.83
PK 7	2022	Critical Thinking	0.41	0.85
PK 8	2023	Critical Thinking	0.40	0.92
PK 9	2022	Critical Thinking	0.45	1.04
PK 10	2022	Critical Thinking	0.47	2.07
PK 11	2024	Critical Thinking	0.44	1.92
PK 12	2023	Critical Thinking	0.31	0.78
PK 13	2021	Critical Thinking	0.50	1.51
PK 14	2024	Critical Thinking	0.40	1.18
PK 15	2024	Critical Thinking	0.41	1.52
PK 16	2024	Critical Thinking	0.39	0.96
PK 17	2021	Critical Thinking	0.34	1.29
PK 18	2022	Critical Thinking	0.51	0.94
PK 19	2022	Critical Thinking	0.35	1.62
PK 20	2024	Critical Thinking	0.19	0.98
PK 21	2022	Critical Thinking	0.16	0.37
PK 22	2021	Critical Thinking	0.44	2.16
PK 24	2022	Critical Thinking	0.40	1.34
PK 24	2021	Critical Thinking	0.30	0.77
PK 25	2021	Critical Thinking	0.28	0.61
PK 26	2023	Critical Thinking	0.32	1.38
PK 27	2022	Critical Thinking	0.30	0.96

Table 3. Fixed and Random effect

	Q	df	p
Omnibus test of Coefficients Model	143.062	1	< 0.001
Test of Residual Heterogeneity	71.385	23	< 0.001

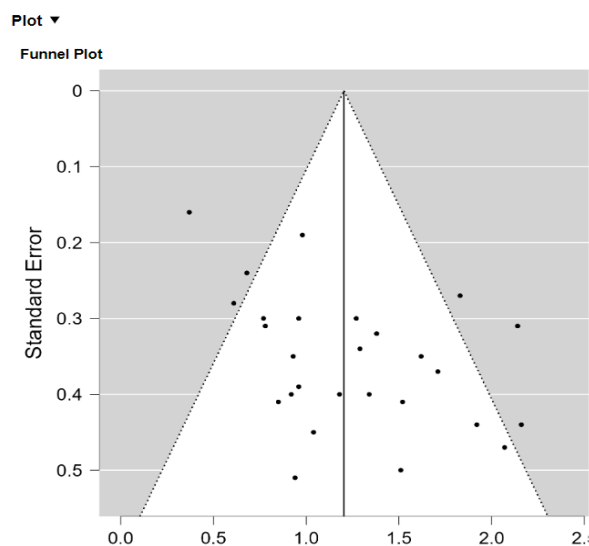


Figure 2. Funnel Plot Standard Error

Based on Figure 2, the analysis of the funnel plot is not yet known whether it is symmetrical or asymmetrical, so it is necessary to conduct a Rosenthal Fail Safe N (FSN) test. The results of the Rosenthal Fail Safe N calculation can be seen in Table 4.

Tabel 4. Fail Safe N

File Drawer Analysis			
	Fail Safe N	Target Significance	Observed Significance
Rosenthal	3407	0.050	< 0.001

Based on Table 4, the Fail Safe N value of 3407 is greater than the value of $5k + 10 = 5(27) + 10 = 145$, so it can be concluded that the analysis of 27 effect sizes in this data is not biased by publication and can be scientifically accounted for. Next, calculate the p-value to test the hypothesis through the random effect model. The results of the summary effect model analysis with the random effect model can be seen in Table 5.

Tabel 5. Mean Effect Size

Coefficient						
	Effect Size (g)	Standard Error	z	p	95 % Coefficient Interval	
					Lower	Upper
Intercept	1.204	0.101	11.961	< 0.01	1.007	1.401

Based on Table 5, the mean effect size value is 1,204; standard error 0.101, so this result shows that there is a positive influence of mobile learning on critical thinking skills in early childhood teacher candidates compared to other learning with a value ($z = 11.961$; $p < 0.001$) with a high influence category. These findings support the theory that technology-based learning can create an environment that supports the development of higher-order thinking skills (Meisaroh & Suparno, 2024). Mobile learning provides flexible access to learning resources and encourages students to actively participate in knowledge exploration. This is in line with previous studies that show that mobile technology is able to increase student engagement, motivation, and learning outcomes, especially in developing critical thinking skills (Jamil et al., 2024; Ramadhan et al., 2024).

The advantage of mobile learning in improving critical thinking skills lies in its ability to provide interactive and contextual learning materials. In this study, students who use mobile learning can access problem-based learning scenarios that are relevant to the challenges in the world of early childhood education (Ayatin et al., 2024). In addition, the use of features such as online discussions, learning videos, and simulations helps students to analyze situations, evaluate various solutions, and develop logical arguments. These results indicate that mobile learning not only provides flexibility in learning, but also builds the necessary skills in professional practice (Eliza et al., 2024). However, this study also identifies several challenges in the application of mobile learning. One of the main obstacles is the technology gap, where some early childhood education students face limited access to devices or stable internet networks (Mugisha et al., 2024). In addition, the level of digital literacy of students also varies, which affects the effectiveness of using mobile learning. To overcome this, higher education institutions need to ensure adequate infrastructure and provide digital literacy training for early childhood education students. This support is important to ensure that all students can make optimal use of mobile learning (Batdı et al., 2024; Luciana et al., 2024).

This research provides important implications for the development of teacher education curriculum. The integration of mobile learning in educational programs needs to be

designed systematically to be able to support the development of students' critical thinking skills (Essien et al., 2024; Lionakis et al., 2023; Tang, 2024). This strategy can include the use of mobile learning as part of project-based learning, collaborative learning, or problem-based learning. Thus, mobile learning is not only a supporting tool, but also a core method that drives the transformation of learning towards the achievement of 21st century skills.

Conclusion

From the results of this meta-analysis, it can be concluded that mobile learning has a positive effect on the critical thinking skills of prospective early childhood education teachers compared to other learning ($g = 1.204$; 95% CI 1.007; 1.401; $p < 0.001$). This finding informs that mobile learning is effective in improving the critical thinking skills of prospective early childhood education teachers. This study shows that mobile learning can be an effective learning strategy to improve the critical thinking skills of Early Childhood Education (ECED) teacher candidates. Therefore, universities need to consider integrating mobile learning technology in the curriculum, especially in courses that require the development of critical thinking skills. The results of this study have significant implications for the development of curriculum and training of prospective early childhood teachers, especially in improving critical thinking skills through the integration of mobile learning. The ECCE teacher education curriculum needs to be designed to accommodate the active use of mobile technology, by adding courses or modules that focus on technology-based learning innovations. In addition, teacher training should include the development of digital literacy and skills in designing interactive problem-based learning through mobile devices. This approach not only supports the improvement of the critical thinking skills of prospective teachers, but also prepares them to create a learning environment that is relevant to the needs of early childhood in the digital age. Educational institutions are also advised to hold training for lecturers to ensure the success of the implementation of mobile learning and conduct continuous evaluation to increase the effectiveness of this method.

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