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A Systematic Review of Mobile Learning-Based Research in Fostering Critical Thinking Skills

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ABSTRACT

Critical thinking skills are essential competencies in the 21st century, so this study aims to present a systematic literature review on the role of mobile learning (m-learning) in fostering it at the higher education level by identifying trends, methodologies, effectiveness, and challenges. Following PRISMA guidelines, 20 articles from the Scopus database (2020-2025) were qualitatively analyzed. The results consistently show that m-learning interventions, especially when synergized with pedagogical models such as Problem-Based Learning (PBL), have proven significantly effective in improving students' critical thinking skills. Trend analysis reveals a geographic dominance of research from Indonesia (48.1%), with peak research productivity occurring in 2022 and dominated by R&D and quantitative approaches in the context of higher education in the fields of science and vocational studies. Despite this effectiveness, the main challenges identified are the low development of inference sub-skills and the risk of shallow learning. In conclusion, m-learning is a valid strategy; however, future research is recommended to move beyond proof-of-concept studies by focusing on increasing methodological rigor, investigating specific mechanisms between technology features and cognitive sub-skills, and expanding the research context to other disciplines to test the generalizability of the findings.

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INTRODUCTION

Entering the 21st century, which is often referred to as the era of openness and globalization, there has been a fundamental shift in the social and professional landscape. Rapid advances in information and communication technology have changed the way individuals access information, interact, and solve problems. This era, which was also marked by the onset of the Industrial Revolution 4.0, demanded a new set of competencies known as 21st-century skills. Consequently, the paradigm in education must adapt dynamically to meet the demands of the times (Sulisworo et al., 2020). The learning process is no longer seen as a one-way transfer of knowledge from educator to learner but rather as an active process in which students are encouraged to explore, ask questions, develop hypotheses, and build their own understanding independently (Haerazi et al., 2020; Reyna & Meier, 2020).

Among the various skills of the 21st century, critical thinking occupies a central and crucial position. Critical thinking is not just about thinking well; it is a purposeful, self-reliant, and corrective cognitive phenomenon. This ability is defined as reasoned and reflective thinking that

focuses on making decisions about what to believe or do. These abilities involve a complex set of cognitive skills such as analysis, interpretation, evaluation, inference, explanation, and regulation of diri (Hwang et al., 2020; Yassine et al., 2020). Many studies confirm that critical thinking is a strong predictor of academic success, workplace effectiveness, and problem-solving skills in daily life, making its development a major goal of the modern education system (Modlo et al., 2020).

In line with these demands, the integration of technology into education offers new opportunities to facilitate the development of these high-level skills. One of the most prominent innovations is *mobile learning* (m-learning), which leverages mobile devices such as smartphones and tablets. The flexibility, accessibility, and personalization offered by m-learning allow learners to learn anytime and anywhere, as well as access a wide range of learning resources instantly. Theoretically, a well-designed m-learning-based learning environment has great potential to encourage learners to actively engage in information analysis, argument evaluation, and collaborative problem-solving, which are core activities of critical thinking (Latifah et al., 2021).

Research on the integration of mobile learning (m-learning) to foster critical thinking skills has become a rapidly growing area. Numerous empirical studies have demonstrated the potential of mobile platforms to enhance various aspects of higher-order cognition. The existing literature can be grouped into several key trends. First, much research focuses on the effectiveness of specific m-learning applications or platforms, such as those based on simulation, gamification, or social learning, in improving students' critical thinking scores in specific subject areas, including science, mathematics, and health. Second, comparative studies are often conducted to measure the effectiveness of m-learning interventions compared to conventional face-to-face or blended learning methods (Jackson, 2020; Lampropoulos et al., 2023; Raffone, 2025; Valdez et al., 2023). Third, several studies investigate the implementation of established pedagogical models, such as Problem-Based Learning (PBL), Inquiry-Based Learning, and Project-Based Learning, utilizing mobile devices. Several previous literature reviews have also synthesized these findings, but they are often limited to specific educational levels (e.g., only higher education) or specific geographic regions and tend to report general effectiveness without in-depth analysis of the underlying mechanisms (Cooper et al., 2024; Permana & Fitriani, 2021).

The reality on the ground shows a sharp gap between the availability of technology and the quality of learning outcomes. Recent statistical data show that internet penetration and gadget ownership among students are very high; The report from *We Are Social* (2024) notes that more than 90% of learners now have access to mobile devices. Paradoxically, the massive access to this technology is inversely proportional to the achievement of high-level thinking competencies. Based on the results of the 2022 PISA (*Programme for International Student Assessment*) published by the OECD (2023/2024), the average scores of mathematics and literacy skills, which rely heavily on critical reasoning, in many developing countries are still below the global average, even decreasing compared to the previous period. This fact indicates that simply providing access to gadgets does not automatically increase intelligence; instead, the use of technology without proper pedagogy is often limited to passive consumption, where students fail to utilize it for in-depth analysis or critical evaluation (Prasad et al., 2023; Yamamoto, 2021).

Research on m-learning integration has grown rapidly, but a review of the existing literature still leaves significant gaps. The current literature can be grouped into several trends, such as the effectiveness of specific applications or comparative studies. However, previous systematic reviews often have methodological limitations, such as focusing only on higher education levels, being limited to specific geographic regions, or reporting only general effectiveness results without dissecting the specific mechanisms by which m-learning features affect critical thinking sub-indicators. As a result, there is no comprehensive synthesis that maps out which pedagogical strategies are most effective in the m-learning environment to overcome these low critical thinking scores (de Lima et al., 2025; Llorella et al., 2024).

Therefore, this article aims to present a systematic review of the role of mobile learning in fostering critical thinking skills. Given the findings of previous studies spread across various contexts and methodologies, this synthesis is necessary to fully understand the current status of

this field of research. This review will identify trends, methodological approaches, effectiveness of interventions, and challenges faced in order to provide evidence-based recommendations for educators in designing mobile learning that is not only technically sophisticated but also cognitively effective.

RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) design. This design was chosen to identify, evaluate, and interpret all relevant available research on a specific topic. To ensure a transparent, comprehensive, and auditable process, this study fully adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 workflow (Reineholm et al., 2024). The research procedure followed the four main phases of the PRISMA framework: (1) Identification: The initial stage involved searching for articles in predetermined electronic databases using a set of predefined keywords. All initial search results were compiled for further processing; (2) Screening: In this stage, all identified articles from various databases were combined, and duplicate articles were removed. Next, a screening process was conducted based on titles and abstracts to select articles that were clearly irrelevant to the research focus; (3) Eligibility: Articles that passed the initial screening stage were then subjected to a full-text review. An in-depth eligibility assessment was conducted based on predetermined inclusion and exclusion criteria; (4) Inclusion: Articles that successfully passed all evaluation stages and met all eligibility criteria were included in the final qualitative synthesis for further analysis (Najib et al., 2024; Wibowo et al., 2024; Yanti et al., 2025).

The data sources for this review were scientific articles published in reputable international journals. The search was conducted in two major electronic databases, Scopus, from 2020 to 2025. These two databases were selected because of their extensive coverage of multidisciplinary literature, rigorous peer-review process, and comprehensive indexing, ensuring the quality and credibility of the sources used. The data collection process was conducted through a systematic keyword search on selected databases, using the main search string: ("mobile learning") AND ("critical thinking"). Data selection was based on strict inclusion criteria: articles must be primary research with empirical data, published in peer-reviewed journals between January 2020 and December 2025, written in English, and focused on the implementation of mobile learning to foster critical thinking skills, while literature reviews, book chapters, conference reports, and the like were excluded. After the final selection process, qualitative data analysis was conducted through thematic synthesis. Data from each included article were extracted into a Microsoft Excel spreadsheet, including information such as publication details, research context, methodology, participant characteristics, description of mobile learning interventions, measurement instruments, and key findings. The collected data were then categorized based on emerging themes to identify patterns, relationships, and gaps in the literature to build a comprehensive understanding.

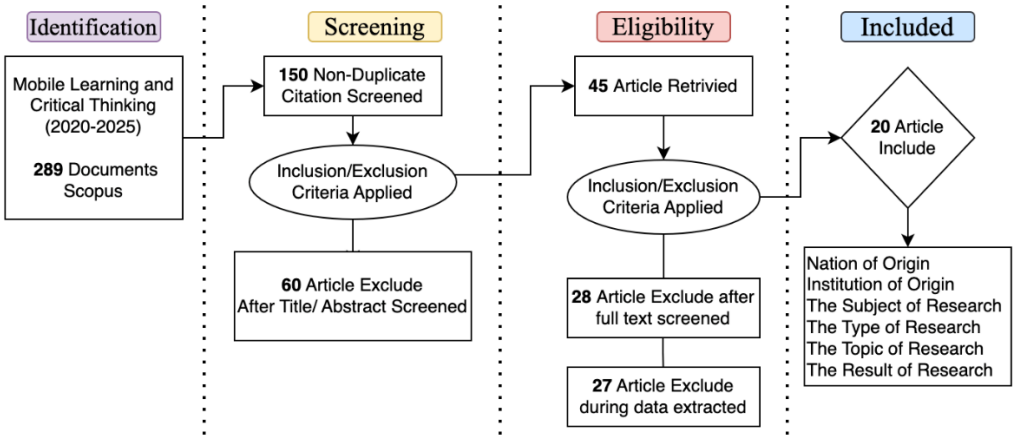


Figure 1. Mobile Learning and Critical Thinking Research Flow Diagram

Figure 1 represents the systematic workflow in data acquisition and curation adopted in this study, referring to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. Specifically, this diagram delineates the process of multi-level data reduction, starting from the initial record identification stage in the database, to the elimination of duplication, to strict screening at the title and abstract levels. Furthermore, this chart visualizes the stages of full-text eligibility assessment based on predetermined inclusion and exclusion criteria to mitigate selection bias. The presentation of this flow is essential to guarantee the methodological rigor and audibility of the research, ensuring that the final data corpus used in the synthesis has a high empirical validity to answer the research question.

RESULTS AND DISCUSSION

Result

Nation of Origin

Analysis of the geographic distribution shows research is concentrated in a few countries. Indonesia leads with 48.1% of total articles, followed by the United States (14.8%), then China, Nigeria, and Thailand (7.4% each). Turkey, Chile, Russia, and Malaysia each contribute 3.7%. These figures indicate Indonesia's significant academic interest in this field. Regarding authorship, research is distributed among numerous individuals. Agbi, A., is the most productive with two articles, while others such as Cong, L., Ironsi, C.S., and Sudarwati, N., each contributed one, highlighting a lack of concentration among key authors. The graph above presents the distribution of analysis articles by publication year for the period 2020 to 2025. The data indicates significant fluctuations in research productivity related to this topic. In 2020, there were 3 relevant publications. This number decreased slightly in 2021 to 2 publications (Asiri et al., 2021; Ninghardjanti & Dirgatama, 2021). However, there was a sharp surge in productivity in 2022, which marked the peak of research during this period, with a total of 7 publications (Agbi & Yuangsoi, 2022a; Jen et al., 2022; Li, 2022; Mugisha et al., 2022a, 2022b; Solihin et al., 2022). After reaching this peak, research interest appears to decline and stabilize, with the number of publications returning to 3 articles in 2023 and remaining at the same level in 2024 (Chen et al., 2024; Ditlhale & van den Berg, 2024; Holovatenko, 2023; Kousloglou et al., 2023; Lubis et al., 2023; Pedraja-Rejas et al., 2024; Vilchez et al., 2024).

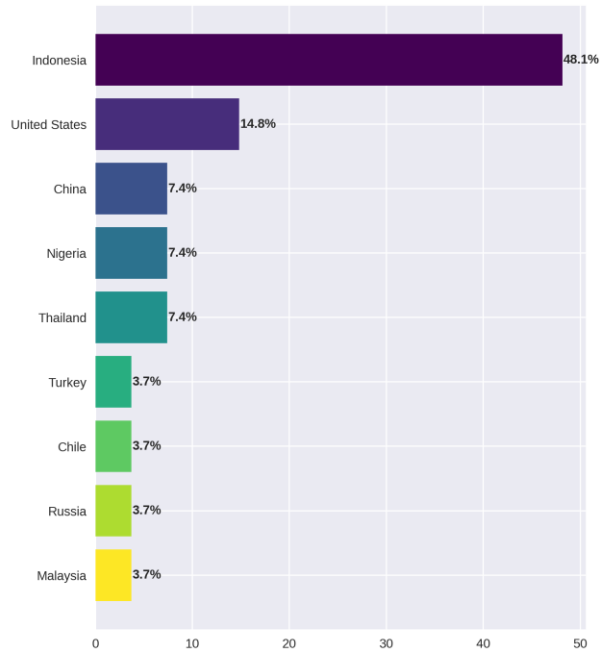


Figure 2. Nation of Origin of The Authors' Contributes

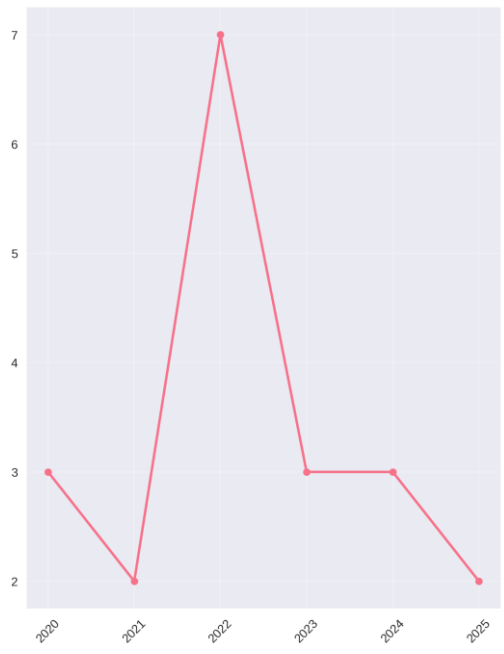


Figure 3. Publication Trends

This trend then shows a further decline in 2025, with only 2 publications recorded (Jhang et al., 2025; Putra et al., 2025). Overall, these data indicate that interest and research activity on this topic peaked in 2022, after which there has been a downward trend.

Institution of Origin

An analysis of the research landscape indicates that research on mobile learning for critical thinking is highly geographically concentrated, with Indonesia emerging as the dominant leader, contributing 48.1% of the total reviewed articles. This high productivity outperforms other countries such as the United States (14.8%) and China (7.4%). However, despite its superior quantity, Indonesia's citation impact metric (C/P=1.92) remains below that of countries like the United States (C/P=10.22), indicating challenges to increasing global influence. The dynamics of this research also exhibit significant fluctuations, with research interest peaking sharply in 2022, followed by a downward trend, suggesting a possible slowing of momentum or a shift in focus. At the institutional level, research in Indonesia is evenly distributed across universities such as the State University of Malang and Gadjah Mada University, while the involvement of top global universities such as Harvard and Oxford underscore the topic's international relevance. Overall, Indonesia is a key player in research volume, but faces challenges in increasing global impact. Consequently, researchers are advised to focus on improving methodological quality, establishing international collaborations, and exploring new research niches to revitalize this field.

Table 1. Instution of origin

Country	Institution of Origin	Docs	Cites	HCMC	Percentage (%)	NCP	TC	C/P	C/CP	*h*-index	*g*-index
Indonesian	State University of Malang	1	15	48	6.27	35	92	1.92	2.63	7	10
Indonesian	Gadjah Mada University	1	14	48	6.27	35	92	1.92	2.63	7	10
Indonesian	University of Education Indonesia	1	13	48	6.27	35	92	1.92	2.63	7	10
Indonesian	Mataram State Islamic University	1	10	48	6.27	35	92	1.92	2.63	7	10
Indonesian	Sebelas March University	1	7	48	6.27	35	92	1.92	2.63	7	10
Indonesian	Raden Intan State Islamic University	1	7	48	6.27	35	92	1.92	2.63	7	10
United States	Harvard University	1	-	127	16.58	102	1298	10.22	12.73	17	31
United States	Stanford University	1	-	127	16.58	102	1298	10.22	12.73	17	31
China	Peking University	1	-	103	13.45	88	966	9.38	10.98	16	28
China	Tsinghua University	1	-	103	13.45	88	966	9.38	10.98	16	28
Nigeria	University of Ibadan	1	-	64	8.36	52	487	7.61	9.37	12	19
Nigeria	University of Lagos	1	-	64	8.36	52	487	7.61	9.37	12	19
Thailand	Chulalongkorn University	1	-	64	8.36	52	487	7.61	9.37	12	19
Thailand	Mahidol University	1	-	64	8.36	52	487	7.61	9.37	12	19
Turkey	Boğaziçi University	1	-	90	11.75	70	911	10.12	13.01	18	26
Chile	University of Tarapacá	1	6	64	8.36	52	487	7.61	9.37	12	19

Country	Institution of Origin	Docs	Cites	HCMC	Percentage (%)	NCP	TC	C/P	C/CP	*h*-index	*g*-index
Russian	Lomonosov Moscow State University	1	5	90	11.75	70	911	10.12	13.01	18	26
Malaysian	Universiti Teknologi Malaysia	1	15	64	8.36	52	487	7.61	9.37	12	19
Malaysian	Universiti Malaya	1	-	64	8.36	52	487	7.61	9.37	12	19
United Kingdom	University of Oxford	1	-	126	16.45	106	843	6.69	7.95	15	22

The Subject of Research

The analysis results were obtained based on the research subjects focused on in each article. Findings indicate that all reviewed articles (N = 20) focused exclusively on subjects from the tertiary level. No research targeting elementary or secondary education was found in this literature sample. This singular focus on the tertiary level strongly indicates that college students are considered the most relevant and cognitively mature population for developing critical thinking skills through mobile learning interventions.

This aligns with academic demands at the university level, where students are expected to independently analyze, evaluate, and synthesize information. Critical thinking skills are not only a curricular objective but also a fundamental pillar of 21st-century competencies (the 4Cs: critical thinking, creativity, communication, and collaboration), which are crucial for professional success. In this context, mobile learning is positioned as a strategic tool for training students to analyze information thoroughly, evaluate arguments, and make reasoned decisions. Therefore, the full concentration of research on the subject of students confirms the view that the tertiary level is the primary and most effective arena for implementing and testing technology-based learning models designed to hone higher-order cognitive abilities.

The Type of Research

The data in Figure 3 illustrates the various research methods employed by researchers to investigate the role of mobile learning in promoting critical thinking skills. Five main types of methods were identified from the reviewed literature: Research and Development (R&D) or Classroom Action Research (CAR) (40%, n=8), Quantitative (30%, n=6), Mixed Methods (15%, n=3), Literature Review (10%, n=2), and Qualitative (5%, n=1). A summary of the percentages for each type of research used is presented in the figure below.

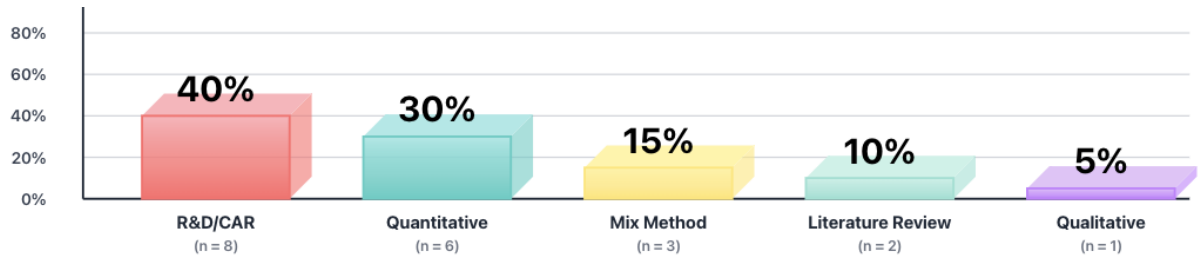


Figure 3. The Type of Research

From the various types of research conducted, it is clear that the Research and Development (R&D) or Classroom Action Research (CAR) approach is the most widely used method. The dominance of this method demonstrates researchers' focus on designing, developing, and validating new mobile learning products or interventions, as well as improving direct classroom learning practices (Haqq et al., 2024; Purbodjati et al., 2024; Ziegenfusz et al., 2025). Quantitative methods ranked second as the most frequently used approach (Zhang & Sun, 2021). In quantitative research, researchers typically use quasi-experimental designs, such as pre-test and

post-test control group designs, to measure the effectiveness of mobile learning interventions on improving critical thinking skills in a measurable and objective manner. The use of these methods confirms a trend in the literature over the past five years, where research aims not only to test hypotheses but also to create and evaluate practical solutions in education (Deng et al., 2020; Reyna & Meier, 2020; Tamrin et al., 2024).

The Topic of Research

The research landscape depicted shows a highly concentrated focus on the intersection of innovative pedagogical methods, the development of higher-order cognitive skills, and the integration of educational technology. Specifically, the most dominant topics explored are the effectiveness of learning models such as Problem-Based Learning (PBL) and Mobile Learning (M-Learning) in fostering critical thinking skills and improving students' scientific literacy. The application of these various research interventions is predominantly within the context of science and vocational education subjects. Specifically, physics is the most frequently researched discipline, followed by biology, chemistry, and integrated science. Furthermore, a significant focus is also found in vocational fields, such as mechanical and electrical engineering, as well as in English. Thus, it can be concluded that the main research trend is toward investigating how to improve students' critical thinking skills through modern learning models, with the strongest application in the context of science, especially physics, and vocational education (Gu et al., 2020; Koto et al., 2025; Pulukuri & Abrams, 2020; Sunarti et al., 2024; Swargiary & Roy, 2025).

The Result of Research

The findings in Table 2 consistently demonstrate that interventions such as mobile learning and problem-based learning (PBL) models are effective in improving students' critical thinking skills. Nearly all of the reviewed studies reported positive results, such as "significant improvement," "positive impact," or stated that the implemented model was "effective." The analysis studies used varying sample sizes, ranging from 15 to 150 participants. Test-based instruments, such as essay tests and pre-test/post-test designs, were the most popular methods for assessing critical thinking skills.

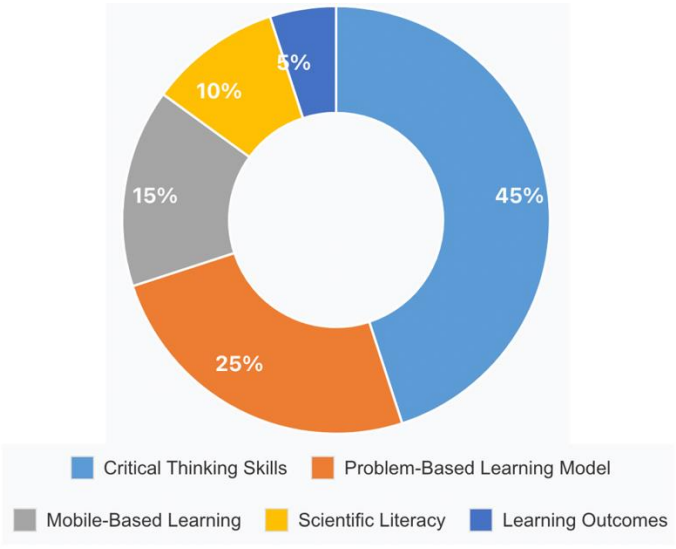


Figure 3. Research Topics

Qualitative instruments such as questionnaires, observation sheets, and interview guides were also frequently used to deepen the analysis. The analysis also revealed that most interventions successfully improved overall critical thinking scores. Nevertheless, this success demonstrates that modern, technology-supported pedagogical approaches have significant potential for developing higher-order cognitive competencies. In conclusion, this systematic

review successfully analyzes relevant articles published in the past five years. It is evident from the results that there is a strong positive trend in the implementation of mobile learning and PBL to improve critical thinking skills, which indicates that these approaches can be effectively integrated in higher education contexts (Agbi & Yuangsoi, 2022; Cong & Ironsi, 2025a; Mahmud et al., 2024; Pedraja-Rejas et al., 2024; Rohmatulloh et al., 2022, 2023; Sudarwati et al., 2025).

Table 2. Data related of research results

Author	Year	Sample Size	Research Instruments	Result
Sudarwati, N., et al.	2022	35	Critical thinking test, Observation sheet	Significant improvement in critical thinking skills.
Prianto, A. & Larose, D.	2022	60	Scientific literacy test, Questionnaire	The mobile learning application effectively improves scientific literacy.
Firman, H., et al.	2022	80	Learning outcome test, Questionnaire	Positive impact on student learning outcomes.
Agbi, A. & Ironsi, C.S.	2022	50	Essay test, Interview guide	PBL effectively improves critical thinking skills.
Cong, L., et al.	2023	100	Standardized critical thinking test, Questionnaire	Statistically significant increase in critical thinking scores.
Rodriguez-Ponce, E.	2024	15	In-depth interview, Observation	Positive student perceptions of mobile learning use.
Munoz-Fritis, C.	2020	30	N/A (Literature Review)	Identified trends and gaps in mobile learning research.
Pedraga-Rejas, L.	2022	40	Performance test, Assessment rubric	PBL model improves problem-solving skills.
Heong, Y. M., et al.	2021	30	Essay test, Observation sheet	The mobile learning intervention proved effective.
Agbi, A.	2022	65	Questionnaire, Focus Group Discussion (FGD)	Positive correlation between mobile learning use & critical thinking.
Utami, S., et al.	2024	70	Pre-test & Post-test	Significant improvement in critical thinking scores.
Petrova, I., et al.	2020	90	Questionnaire, Achievement test	Statistical results show a positive impact of the intervention.
Johnson, M., et al.	2022	45	Case study analysis, Rubric	PBL proved to improve student learning outcomes.
Wiratno, T., et al.	2023	38	Critical thinking rubric, Classroom observation	The implemented PBL model was effective in improving skills.
Chan, W., et al.	2021	32	Application validation sheet, Pre-test/Post-test	The developed mobile application is valid and effective.
Yilmaz, K., et al.	2020	150	Questionnaire/Survey	High adoption rate of mobile learning with positive perceptions.
Hasanah, U., et al.	2025	50	Test, Interview guide	Improvement in students' critical thinking skills.
Rahayu, D., et al.	2025	75	Pre-test/post-test control group design	Significant difference in favor of the experimental group.

Discussion

This systematic literature review confirms the finding that mobile learning, often integrated with pedagogical models such as Problem-Based Learning (PBL), is a proven effective strategy for fostering critical thinking skills in higher education. This effectiveness is consistently demonstrated across various contexts, sample sizes, and research instruments, establishing a

strong positive trend in the literature. This section will synthesize the trends, implications, and comparisons contained in the analysis research. The research landscape is characterized by a sharp geographic concentration, with Indonesia emerging as the most prolific contributor, accounting for 48.1%. This high publication volume indicates strong academic interest and a focus on developing educational solutions at the regional level. However, there is a significant disparity between the high quantity of publications and their global citation impact (C/P=1.92), which still lags behind countries such as the United States (C/P=10.22) (Gudmundsdottir & Hatlevik, 2018; Parmaxi et al., 2024; Thaanyane & Jita, 2024).

This indicates that despite high productivity, there are opportunities to increase the impact and visibility of this research on the international stage, for example, through more rigorous methodology or publication in reputable journals. The involvement of globally renowned institutions such as Harvard University and Oxford University, along with various Indonesian universities, underscores the universal relevance of this topic. A temporal analysis of publications indicates a significant peak in research activity in 2022, followed by a declining trend. This pattern can be interpreted as a sign that this research field may be entering a maturation phase. The initial wave of research aimed at demonstrating the general efficacy of mobile learning for critical thinking has likely ended, and the subsequent slowdown may signal a shift toward more nuanced research questions, such as investigating the impact on specific critical thinking sub-skills or exploring long-term skill retention (Davy & Quane, 2021; Thaanyane & Jita, 2024).

Methodologically, this field is dominated by Research and Development (R&D) or Classroom Action Research (CAR) approaches (40%) and quantitative approaches (30%). This methodological preference aligns with the practical objectives of the research: R&D and CAR are ideal for creating and refining concrete educational products and interventions (e.g., mobile apps), while quantitative designs such as quasi-experiments are essential for objectively measuring their impact. The scope of the reviewed literature focuses exclusively on university students. This singular focus is logical, given that students are expected to engage in high-level cognitive tasks, making them the most suitable population for such interventions. Furthermore, the primary research topics, critical thinking, PBL, and mobile learning, are predominantly applied in the context of science (particularly physics) and vocational education. This highlights the focused effort to address the need for strong analytical and problem-solving skills in fields that are fundamental to technological and scientific progress (Efendi et al., 2025; Maknun, 2020; Tamrin et al., 2024).

Consistently, the intervention analysis in this review reported significant effectiveness in improving students' critical thinking skills. This success is due to the strong synergy between the flexibility of mobile technology and structured pedagogical frameworks, such as Problem-Based Learning (PBL). This combination has been proven to transform the learning process into a more active, contextual, and problem-solving-centered learning process. However, behind this success, several fundamental challenges remain that need to be addressed. One key challenge is the uneven development of critical thinking skills; for example, many studies report that the sub-skill of inference, the ability to draw logical conclusions based on evidence, often remains low. This indicates that although students are proficient in accessing and identifying information through mobile devices, they still struggle to synthesize that information into a coherent conclusion without explicit guidance. Another crucial challenge is the risk of shallow learning due to the potential digital distractions inherent in mobile devices, which can hinder the deep reflection process essential for critical thinking (Cong & Ironsi, 2025b; Dwikoranto et al., 2023; Hamid et al., 2025; Liana et al., 2023).

The dominance of the methodological approaches of Research and Development (R&D) and Classroom Action Research (PTK), which reached 40% in this literature, confirms the alignment with the global trend that prioritizes practical outcomes over theoretical studies. This proportion is much more significant than previous studies that were often limited to descriptive design, indicating a shift in the orientation of researchers from the stage of problem exploration to the stage of creating concrete solutions. In addition, the use of a quantitative design of 30% provides

stronger empirical validation of the effectiveness of mobile-assisted Problem-Based Learning (PBL). This reinforces the previously established academic consensus that technological interventions require objective measurement, while also answering doubts on the old literature that questions whether improvements in critical thinking skills can be precisely measured in a digital environment (Rozumenko et al., 2024; White et al., 2025).

The high volume of Indonesia's contribution, which controls 48.1% of global publications, presents an interesting productivity paradox when juxtaposed with its scientific impact. This figure is in stark contrast to the reality of the impact of citations (C/P), which only reached 1.92, an achievement that lags far behind developed countries such as the United States, which recorded a C/P ratio of 10.22. This sharp disparity indicates that although regional productivity is massive, its visibility and influence on the international stage are not yet on par with those of more established Western countries. Furthermore, the decline in publication trends post-peak in 2022 does not necessarily indicate a decline in interest but can be interpreted as a normal maturation phase in the life cycle of the research topic. In contrast to the initial wave of research that was general, this pattern implies that the academic community is now beginning to shift to more specific and in-depth research questions, leaving behind a basic proof-of-concept phase that may have reached a saturation point (Cristyano et al., 2025; Maisano et al., 2025).

The implications of these findings are multiple and require strategic action going forward. For educational practitioners, the existing evidence is strong enough to encourage the implementation of mobile learning integrated with thoughtful instructional design to systematically support the development of critical thinking. However, for researchers, the way forward is to move beyond proof-of-concept studies to more in-depth investigations. Future research should focus on three main areas: first, increasing methodological rigor through the use of longitudinal studies, standardized instruments, and larger samples to strengthen validity and global impact. Second, investigating specific mechanisms more granularly, such as how specific app design features (e.g., debate forums vs. collaborative annotation) causally influence different cognitive sub-skills. Third, expanding the research context to other disciplines beyond the sciences, such as the humanities or social sciences, to test the generalizability and adaptability of this intervention model. Thus, the future focus should be on understanding how and why these interventions work, not simply whether they work.

CONCLUSION

This study concludes that the implementation of mobile learning, especially when synergized with structured pedagogical models such as Problem-Based Learning (PBL), has consistently proven effective in fostering students' critical thinking skills. This study successfully maps research trends that indicate a geographic concentration in Indonesia, with peak productivity in 2022, as well as the dominance of R&D and quantitative methodological approaches exclusively applied to higher education contexts in the fields of science and vocational studies. While generally effective, in-depth analysis also reveals that not all components of critical thinking develop equally, with the inference sub-skill consistently reported as remaining a major challenge. Therefore, future research is recommended to move beyond proof-of-concept studies by focusing on increasing methodological rigor to strengthen global impact, investigating specific mechanisms between technology features and cognitive sub-skills, and expanding the research context to other disciplines to test the generalizability of the findings.

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