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The Impact of Mobile Learning on Physics Education: A Systematic Literature Review

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Abstract

Mobile learning has become a significant medium in the educational landscape, especially with the increased usage of smartphones among students and educators. This Systematic Literature Review (SLR) aims to explore the impact of mobile learning on the transformation of physics education. This study obtained 50 out of 200 articles selected based on their relevance to the theme of mobile learning in physics education, citation metrics, and publication date between 2019 and 2024. The review highlights a significant increase in mobile learning research, with the rise occurring in 2020 due to the COVID-19 pandemic, which emphasized the growing potential of mobile learning for remote education. Mobile learning enhances the accessibility, engagement, and effectiveness of physics education by making the learning process more interactive, fostering student independence, and improving learning outcomes. The review also identifies improvements in students' critical thinking and problem-solving skills as key benefits of mobile learning in physics. However, it also highlights the necessity of regulations to prevent misuse and safeguard academic integrity. Practical recommendations for educators include integrating mobile learning with project-based approaches to improve conceptual understanding and student engagement in physics. This study suggests that mobile learning has a transformative role in physics education, opening up new avenues for innovation and further research.

Keywords: mobile learning, physics learning, systematic literature review (SLR)

INTRODUCTION

The rapid evolution of mobile technology has created numerous opportunities for developing innovative teaching techniques that leverage mobile devices, enabling schools, teachers, and students to meet future educational demands (Khaokhajorn, 2020; Huseyin, 2023). Mobile devices are now integral to modern life, significantly influencing education. Indonesia, one of the countries with the highest smartphone and internet user populations, reported 353.8 million mobile connections in 2023 (Kemp, 2023). This widespread smartphone ownership provides unique opportunities to optimize its use as a learning medium, particularly in physics education, where abstraction and engagement often pose challenges (Wang, 2023; Saputra et al., 2020).

Mobile Learning (M-Learning) is an educational approach that utilizes mobile devices and digital technology to facilitate active, location-independent, and time-flexible learning experiences (Zhai & Shi, 2020). By transforming traditional teacher-centered instruction into student-centered, interactive learning, M-Learning enhances accessibility and engagement (Eveline, 2019). M-Learning has shown promising potential in physics education for creating dynamic and innovative learning environments, improving students' conceptual understanding, and addressing abstract physics concepts through interactive simulations, experimental videos, applications, and gaming-based learning (Bano, 2018; Sholina et al., 2023; Muliyati et al., 2024). M-Learning can create learning according to individual needs and learning styles, providing opportunities for students to access materials independently and repeat difficult concepts (Ninghardjanti et al., 2021; Astuti et al., 2018).

The utilization and significance of mobile learning can positively impact both teachers and students (Wijaya et al., 2019). Students can access learning resources anytime and anywhere and manage their study materials according to their own pace and needs (Zhalgasbekova et al., 2018). Additionally, students’ strong interest in Android-based devices and proficiency in using them can be leveraged as an effective learning tool to enhance their interest in studying physics (Zhai & Zhang, 2019). Android-based physics learning media aims to improve conceptual understanding through an interactive and flexible approach, especially in distance learning (Sunaryo et al., 2021). Android-based media ensures wide accessibility without device limitations, enabling students to learn independently with a more in-depth and applicable experience (Aji et al., 2020; Simanjuntak et al., 2018; Astuti et al., 2017). Thus, Android-based mobile learning provides a significant opportunity to support physics education (Dasilva et al., 2019; Demir & Akpinar, 2018).

Despite the growing interest in Mobile Learning, research synthesizing its impact specifically on physics education remains limited, particularly during pivotal periods such as the COVID-19 pandemic. This systematic literature review aims to address this gap by analyzing articles published between 2019 and 2024. The review explores the evolution of mobile learning research in physics education, the methods and objectives employed, and the specific physics concepts addressed. By presenting current trends and practices, this study highlights the transformative potential of M-Learning in modernizing physics education and its implications for teaching and learning practices. The research questions guiding this study are as follows: 1) How has the research on Mobile Learning in physics education evolved between 2019 and 2024?; 2) What methods and objectives have been employed in these studies?; and 3) What physics concepts have been addressed in the context of Mobile Learning?

METHODS

This study employs the Systematic Literature Review (SLR) method to identify, analyze, and synthesize previous research utilizing Mobile Learning media in physics education. The SLR process was conducted in adherence to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and reproducibility. The methodology involved the following steps:

1. **Identification**
   A comprehensive search was conducted using high-quality databases, including Scopus, Web of Science, ERIC, Elsevier, and Springer. Google Scholar was used as a supplementary source to identify potentially relevant studies, although non-peer-reviewed articles were excluded to maintain reliability.
2. **Screening**
   The initial pool of 200 articles was screened based on predefined inclusion and exclusion criteria, such as publication year (2019–2024), relevance to mobile learning in physics education, and peer-reviewed status.
3. **Eligibility**
   Articles were further assessed for relevance and quality, with a focus on those addressing the integration of Mobile Learning in physics education.
4. **Inclusion**
   A total of 50 articles were selected for detailed analysis, representing a focused yet comprehensive literature sample.

The data collection process is summarized in FIGURE 1, which illustrates the systematic approach used in this review.

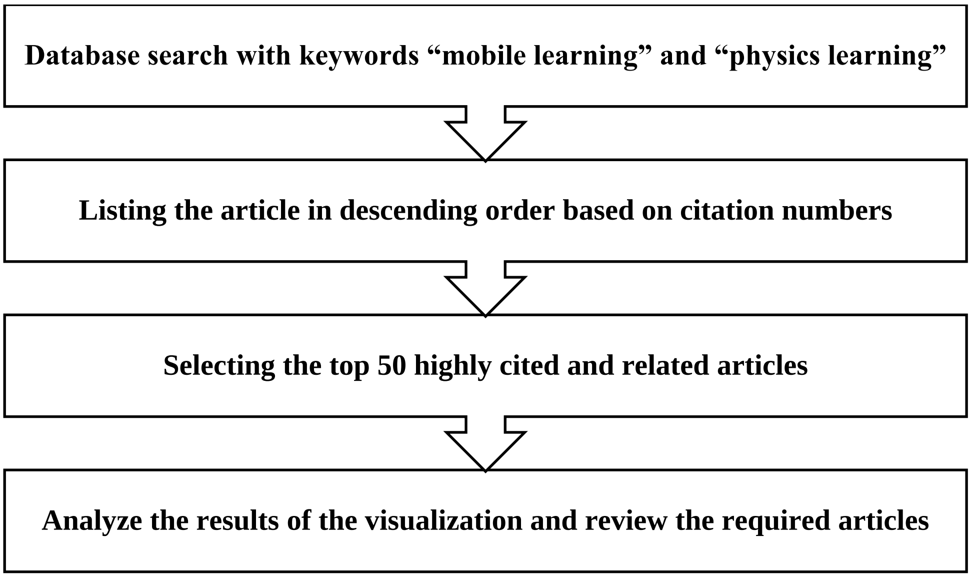

FIGURE 1. Data collection procedure

Data from the selected articles were analyzed using thematic analysis to identify key trends, challenges, and research gaps in Mobile Learning for physics education. The analysis considered various indicators, including the year of publication, research type, subject, topic, treatment, data collection instruments, and data analysis methods. The findings were then synthesized and presented in tables and bar charts to provide a clear and detailed overview of the state of knowledge in this field.

By following this rigorous systematic approach, this study ensures a reliable literature synthesis, offering valuable insights and directions for future research in Mobile Learning for physics education.

RESULTS AND DISCUSSION

FIGURE 2 shows the number of articles related to mobile learning in physics education from 2019 to 2024. From 2019 to 2024, 50 articles had the highest number of citations. These articles are related to Mobile Learning in Physics Education.

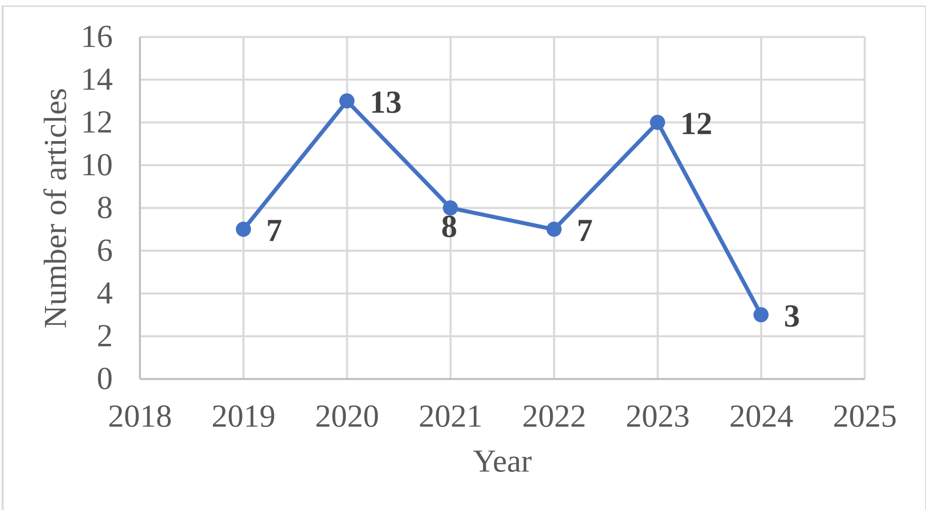

FIGURE 2. Articles published from 2019 to 2024

FIGURE 2 illustrates the trend of the most cited publications on Mobile Learning, featuring the top 50 articles published between 2019 and 2024. According to FIGURE 2, there was an increase in articles on Mobile Learning published in 2020, with 13 articles. This rise was due to the COVID-19 pandemic, which necessitated remote learning, including Physics Education (Edeh, 2023). As a result, many Physics education studies focused on Mobile Learning as the best alternative medium for remote learning. This is evident from the significant increase from 7 articles in 2019 to 13 articles in 2020. A study by Mutambara & Bayaga (2021) similarly observed that the pandemic accelerated the adoption of digital tools, highlighting Mobile Learning as a critical component in maintaining educational continuity, particularly in STEM fields.

A similar trend occurred in 2023, with 12 articles published, up from 8 articles in 2021 and 7 articles in 2022. Besides remote learning, the rapid advancement of technology in 2023 also contributed to the increase in research on Mobile Learning, emphasizing its application in Physics education. Furthermore, the importance of implementing STEM (Science, Technology, Engineering, and Mathematics) and the 4C skills, critical thinking and problem-solving, creativity and innovation, communication, and collaboration in Physics education also played a role. In 2024, only 3 articles have been published so far, as the year is still ongoing, and there is a high likelihood that research on Mobile Learning will increase further this year.

TABLE 1. Percentage of research methods in each year

Research Methods	**2019 (N=7)**	**2020 (N=13)**	**2021 (N=8)**	**2022 (N=7)**	**2023 (N=12)**	**2024 (N=3)**
Mixed Method	43%	23%	25%	58%	17%	0%
Qualitative	14%	31%	38%	14%	25%	0%
Quantitative	29%	31%	12%	14%	33%	67%
SLR	14%	15%	25%	14%	25%	33%

TABLE 1 reveals the distribution of research methods employed in Mobile Learning studies related to physics education between 2019 and 2024. Quantitative and mixed methods dominate the research landscape, with mixed methods peaking at 58% in 2022 and quantitative methods increasing significantly to 67% in 2024. The popularity of these methods stems from their ability to measure the effectiveness of Mobile Learning and provide comprehensive insights into numerical and contextual data. However, relying on these two methods indicates a narrow methodological scope, which may limit the exploration of deeper, qualitative insights into learner experiences or systemic challenges in physics education.

In contrast, Systematic Literature Reviews (SLR) are the least utilized, with their highest representation at 33% in 2024. This trend suggests a missed opportunity to synthesize existing research comprehensively, identify overarching trends, and address gaps in the field. As noted in previous reviews, SLRs are critical in bridging diverse findings and providing a roadmap for future studies (Crompton & Burke., 2018). Moreover, despite their value in capturing in-depth perspectives, qualitative methods have shown inconsistent application, with no usage recorded in 2024. Future research should focus on integrating underutilized methods like SLR and qualitative approaches to enrich understanding and drive innovation in Mobile Learning for physics education.

The lack of emphasis on analyzing and developing mobile learning highlights a significant gap in current research. As previous studies have indicated, innovation in mobile learning requires a comprehensive understanding of its evolution and active efforts to improve its capabilities (El-Sofany et al., 2020; Wingkvist & Ericsson, 2011). The limited focus on development could hinder the creation of new tools or methods tailored to physics education. Future research should prioritize not only the evaluation but also the design and analysis of mobile learning systems to ensure their sustainability and adaptability to emerging educational needs.

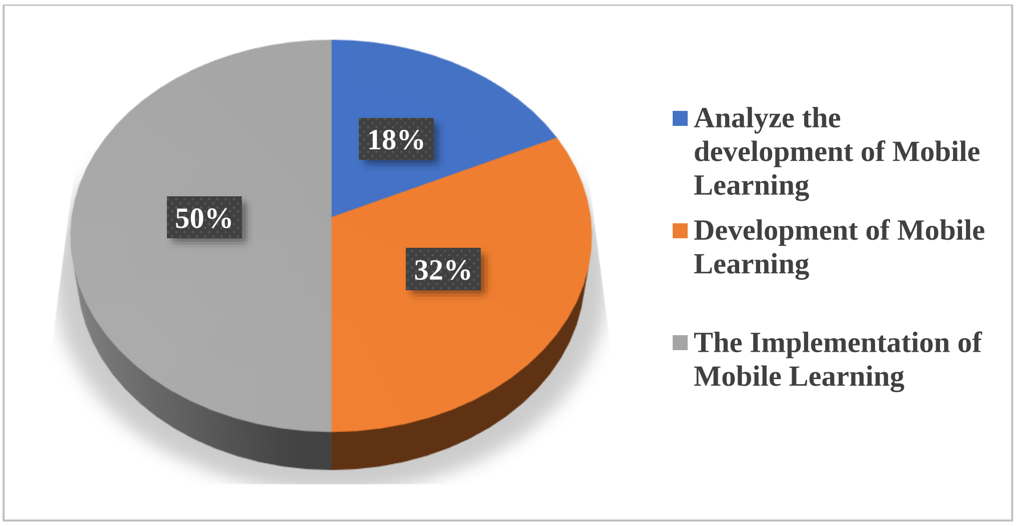

FIGURE 3. Percentage of research purpose

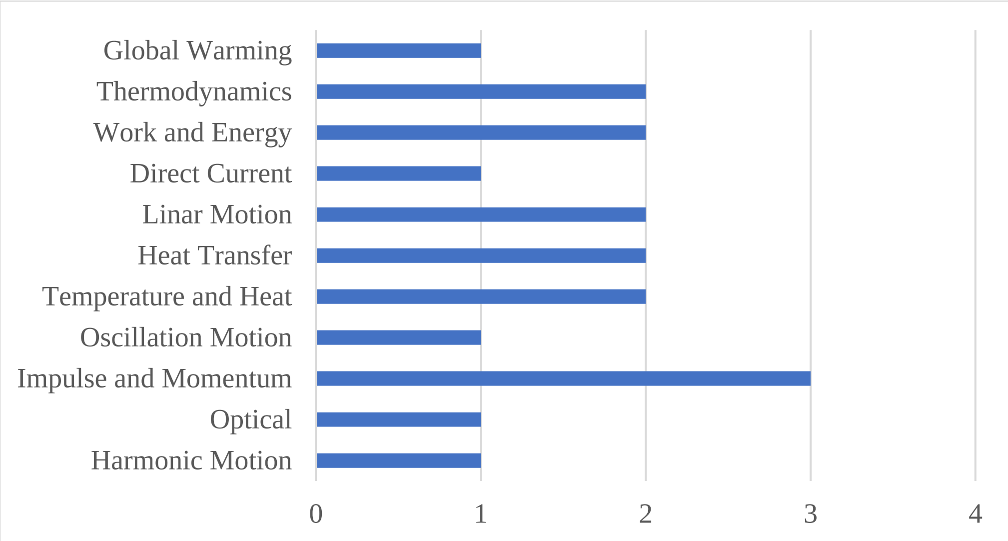

FIGURE 4. Distribution of physics concepts used in mobile learning from 2019 to 2024

FIGURE 4 highlights the distribution of 11 physics concepts used in mobile learning research from 2019 to 2024. The dominance of Impulse and Momentum as the most frequently used concepts indicates a focus on topics that are relatively straightforward to model and simulate in digital media. Similarly, concepts such as Thermodynamics, Work and Energy, Linear Motion, Heat Transfer, and Temperature and Heat, ranked second, align with fundamental principles commonly taught at various education levels. However, this preference for certain topics suggests a narrow focus that may overlook the potential of mobile learning to address more complex or abstract physics concepts, such as those involving wave phenomena or electromagnetic interactions.

Interestingly, less commonly applied concepts such as Global Warming, Direct Current, Oscillation Motion, Optical, and Harmonic Motion highlight potential gaps in research. The limited exploration of these concepts may reflect the challenges of integrating them into mobile learning tools, especially those requiring advanced interactivity or visualization (Christensen & Knezek, 2017). Expanding research to include underrepresented topics could enhance the versatility of mobile learning in physics education. Future efforts should prioritize developing and testing innovative mobile learning applications for these less explored areas to provide students with a more comprehensive understanding of physics.

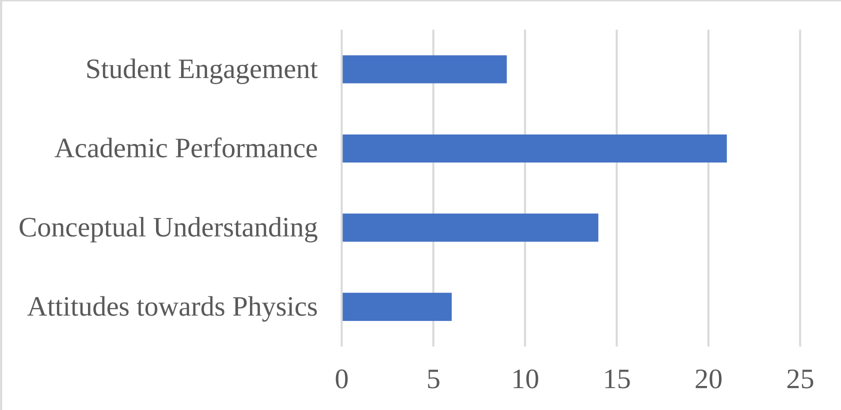

FIGURE 5. The outcomes measured in studies on mobile learning from 2019 to 2024

FIGURE 5 highlights the outcomes most commonly measured in studies on mobile learning in physics education from 2019 to 2024. Academic performance is the most frequently assessed aspect, reflecting the persistent emphasis on improving students' grades and test scores as primary indicators of educational success. While this focus is important, it suggests a traditional evaluation framework that may not fully capture the broader benefits of mobile learning. Conceptual understanding, the second most commonly measured outcome, emphasizes the need for students to develop a deeper grasp of physics principles rather than merely memorizing formulas. This aligns with the growing recognition of the importance of fostering critical thinking and problem-solving skills through physics education.

Interestingly, student engagement ranks third, reflecting an increasing awareness of its critical role in achieving meaningful learning outcomes. Engaging students actively in the learning process can enhance retention and motivation, yet this area is still less researched than academic performance and conceptual understanding. The least explored outcome is students' attitudes toward physics, a key factor in shaping long-term interest and motivation in the subject. Previous studies (Smith et al., 2022) have shown that positive attitudes toward physics can significantly influence students' persistence and success in STEM fields. Future research should balance the focus across these outcomes with greater attention on student engagement and attitudes to ensure a more holistic understanding of mobile learning's impact. TABLE 2 summarizes mobile learning interventions in physics education from 2019 to 2024, with details on the types of tools and methods used.

TABLE 2. Mobile Learning interventions in physics education from 2019 to 2024

Type of Mobile Learning Tool	Description of Tool	Learning Methods
Physics Learning Apps	Mobile apps for hands-on experiments and data collection	Simulated experiments, Self-Directed Learning
Online Collaborative Platforms	Platforms like *Google Classroom* for collaborative learning	Cooperative Learning
Interactive Simulations	Simulations using tools like *PhET* for experimenting with virtual physics scenarios	Simulated experiments, Cooperative Learning
Video-Based Learning	Platforms like *YouTube* and animations on physics topics	Self-Directed Learning
Game-Based Learning	Educational games, such as Physics Games to teach physics through gameplay	Problem-Based Learning
Augmented Reality (AR) Apps	AR-enabled apps for 3D visualizations of physics	Experiential Learning
Virtual Reality (VR) Simulations	VR simulations allowing immersive experiences for complex physics concepts	Experiential Learning

TABLE 2 illustrates the diversity of mobile learning interventions in physics education from 2019 to 2024, emphasizing the increasing integration of advanced tools and interactive methods. Physics learning tools that utilize technology such as applications, interactive simulations, and game-based learning can be used as facilities for self-directed problem-based learning approaches. These interventions allow students to engage in simulated experiments, explore abstract concepts interactively, and apply theoretical knowledge to practical situations. For instance, augmented reality (AR) and virtual reality (VR) tools provide immersive and experiential learning experiences, making complex concepts like 3D motion or electromagnetic fields more accessible and engaging. This technological shift demonstrates the potential of mobile learning to transform physics education into an interactive and personalized experience.

Despite these advancements, there remain gaps in the application of mobile learning tools, particularly in addressing diverse learning styles and ensuring equitable access. While AR and VR offer transformative possibilities, their adoption is often limited by high costs and infrastructure requirements, which can exclude students in under-resourced regions. Furthermore, as noted in prior reviews, mobile learning interventions often focus on specific methods, such as self-directed or problem-based learning, with less emphasis on fostering long-term conceptual understanding or critical thinking skills. Future research should explore the scalability and adaptability of these tools, ensuring they are accessible to a wider audience while addressing comprehensive educational objectives in physics learning. TABLE 3 shows the analysis of the 10 articles with the highest citations from 2019 to 2024.

TABLE 3. Top 10 articles with the highest citations from 2019 to 2024

Authors and Year	Title	Journal	Total Citations	Educational Level and Country	Research Results
Darmaji, D., et al., (2019)	Mobile learning in higher education for the industrial revolution 4.0: Perception and response of physics practicum	International Journal of Interactive Mobile Technologies	130	University, (Indonesia)	Mobile learning is a valuable tool in the context of the Industrial Revolution 4.0, offering numerous benefits for student engagement and understanding in physics practicum. Despite the challenges, the positive perceptions and responses from students highlight the potential of mobile learning to transform higher education practices.
X Zhai, M Zhang, M Li, X Zhang, (2019)	Understanding the relationship between levels of mobile technology use in high school physics classrooms and the learning outcome	British Journal of Educational Technology	63	High School, (China)	There is a positive relationship between the levels of mobile technology use in high school physics classrooms and student learning outcomes. High levels of technology integration lead to improved performance, increased engagement, and greater conceptual understanding. The study emphasizes the importance of addressing technical challenges and ensuring teacher readiness to fully leverage the benefits of mobile technology in education.

Authors and Year	Title	Journal	Total Citations	Educational Level and Country	Research Results
Dasilva, B. E., et al., (2019)	Development of android-based interactive physics mobile learning media (IPMLM) with scaffolding learning approach to improve HOTS of high school students in Indonesia	Journal for the Education of Gifted Young Scientists	63	High School, (Indonesia)	The Android-based interactive physics mobile learning media (IPMLM) with a scaffolding learning approach is effective in improving higher-order thinking skills among high school students. The study demonstrates that well-designed mobile learning tools can significantly enhance student engagement, motivation, and cognitive development in physics education.
Zhai, X., & Shi, L., (2020)	Understanding How the Perceived Usefulness of Mobile Technology Impacts Physics Learning Achievement: a Pedagogical Perspective	Journal of Science Education and Technology	43	High School, (China)	The perceived usefulness of mobile technology significantly impacts students' learning achievement in physics. Students who view mobile technology as useful are more likely to engage with the content and perform better academically. The study highlights the importance of addressing students' attitudes towards technology to maximize its educational benefits.
Wijaya, R. E., et al., (2021)	Development of mobile learning in learning media to improve digital literacy and student learning outcomes in physics subjects: systematic literature review	Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences	38	Broad range of educational, (Indonesia)	Mobile learning media play a crucial role in improving digital literacy and student learning outcomes in physics education. The findings from the reviewed studies suggest that mobile learning can make physics education more interactive, engaging, and effective. However, addressing challenges related to access, technical issues, and teacher readiness is essential for successful implementation.
Eveline, E., et al., (2019)	Development of interactive physics mobile learning media for enhancing students' HOTS in	Jurnal Penelitian & Pengembangan Pendidikan Fisika	29	Secondary education level, (Indonesia)	The development and implementation of interactive physics mobile learning media with a scaffolding learning approach is beneficial in enhancing students' higher-order thinking skills in the topics of impulse and

Authors and Year	Title	Journal	Total Citations	Educational Level and Country	Research Results
	impulse and momentum with scaffolding learning approach				momentum. The study demonstrates the potential of mobile learning tools to transform physics education by making it more interactive, engaging, and effective.
Tuada, R. N., et al., (2020)	Physics mobile learning with scaffolding approach in simple harmonic motion to improve student learning independence	Journal of Physics: Conference Series	16	High School, (Indonesia)	The physics mobile learning application with a scaffolding approach is effective in improving student learning independence in the topic of simple harmonic motion. The study demonstrates that interactive and supportive mobile learning tools can significantly enhance students' ability to learn independently and understand physics concepts more deeply.
Gebze, D. A., & Perwati, S., (2020)	Improving problem-solving ability in physics through android-based mobile learning application	Journal of Physics: Conference Series	14	High School, (Indonesia)	The Android-based mobile learning application is an effective tool for improving students' problem-solving abilities in physics. The study demonstrates that interactive and user-friendly mobile applications can significantly enhance students' engagement, motivation, and performance in physics.
Daineko, Y. A., et al., (2022)	Development of a Mobile e-Learning Platform on Physics Using Augmented Reality Technology	International Journal of Interactive Mobile Technologies (IJIM)	8	University, (Kazakhstan)	The mobile e-learning platform using AR technology is an effective tool for teaching physics. The study demonstrates that AR can provide a more interactive and engaging learning experience, leading to improved educational outcomes in physics.
Momox, E., & Ortega De Maio, C., (2020)	Computer-based learning in an undergraduate physics course: Interfacing a mobile phone and matlab to study oscillatory motion	American Journal of Physics	8	University, (Mexico)	The use of computer-based learning tools, such as mobile phones and MATLAB, is effective in enhancing the learning experience in an undergraduate physics course. The study demonstrates that this approach can improve students' understanding of oscillatory motion and

Authors and Year	Title	Journal	Total Citations	Educational Level and Country	Research Results
					develop their analytical skills.

Research on mobile learning in physics education from 2019 to 2024 reveals that integrating mobile learning tools into instruction can have a profound positive impact. Mobile learning enhances physics education's flexibility, interactivity, and effectiveness, improving student learning outcomes and fostering critical thinking skills. These tools address modern educational challenges by offering personalized learning experiences that adapt to diverse learner needs, making them particularly effective in engaging students and enhancing conceptual understanding.

Over the years, the scope of mobile learning research has expanded significantly. Early studies predominantly focused on evaluating the effectiveness of mobile apps and simulations in increasing student engagement and comprehension of physics concepts. Recent research, however, has shifted towards exploring innovative pedagogical integrations, such as STEM. This development highlights mobile learning's potential to facilitate collaborative, project-based experiences that nurture higher-order thinking skills, creativity, and problem-solving abilities. The increasing interest in integrating mobile learning with STEM pedagogies indicates its potential to align education with 21st-century skill requirements (Asmiliyah et al., 2021).

The effectiveness of different mobile learning interventions varies depending on the learning context and objectives. Mobile apps excel in delivering interactive and personalized content, while simulations are particularly effective for hands-on virtual experiments that replicate real-world phenomena. Meanwhile, educational games stand out in fostering collaboration, critical thinking, and creativity, especially when integrated into STEM-PjBL frameworks. This adaptability demonstrates mobile learning tools' versatility in addressing independent and collaborative learning goals. Ultimately, choosing the right mobile learning intervention depends on the educational context, learning objectives, and the specific needs of students.

Despite these advancements, several limitations in mobile learning research should be addressed to maximize its impact. Many studies, while innovative, suffer from small sample sizes, lack of rigorous control over external variables, and limited generalizability. Moreover, researcher and participant biases may affect the validity of findings, making it essential to interpret results cautiously. A more rigorous research design and robust methodologies are needed to ensure that findings are reliable and applicable across diverse educational settings.

In conclusion, research from 2019 to 2024 demonstrates the significant potential of mobile learning to transform physics education. However, future studies should aim to overcome existing limitations by adopting more robust methodologies and exploring underrepresented areas, such as their long-term impact on student attitudes and critical thinking skills. By addressing these gaps, researchers can contribute to a more comprehensive understanding of mobile learning's role in shaping innovative and effective physics education for the future.

CONCLUSION

This study presents the findings of a systematic literature review on the impact of mobile learning in physics education from 2019 to 2024. Mobile learning enhances accessibility, engagement, and effectiveness in physics education by fostering deeper conceptual understanding and improving learning outcomes. The review highlights its role in creating interactive, flexible, and student-centered environments that align with 21st-century educational demands. It also identifies trends, evaluates the effectiveness of various interventions, and explores their alignment with innovative pedagogies like STEM-PjBL.

However, this study has limitations, including the exclusion of non-English articles, which may restrict the generalizability of findings to non-Western contexts, and reliance on specific databases, potentially omitting other relevant studies. Future research should address these gaps by integrating gamified approaches, exploring long-term impacts on students' creativity and collaboration, and using rigorous methodologies with diverse populations. Despite these limitations, this review underscores the transformative potential of mobile learning in physics education and its capacity to foster engagement and higher-order thinking skills.

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