



Effectiveness of digital learning media in teaching locomotor movements to elementary student

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Received: 6 Desember 2025; Revised: 30 Juni 2026; Accepted: 3 Juli 2026

Abstrak: Di tengah perkembangan era digital yang semakin pesat, integrasi teknologi dalam dunia pendidikan menjadi sebuah kebutuhan yang tidak terelakkan, terutama untuk menyesuaikan dengan karakteristik dan ekspektasi siswa masa kini. Meskipun demikian, pemanfaatan media pembelajaran digital dalam pendidikan jasmani khususnya pada pengajaran keterampilan gerak dasar lokomotor seperti berjalan, berlari, dan melompat masih belum optimal dan cenderung terbatas. Penelitian ini bertujuan untuk mengkaji sejauh mana efektivitas penggunaan permainan edukatif berbasis mobile dalam meningkatkan keterampilan lokomotor siswa sekolah dasar. Penelitian dilakukan dengan desain pra-eksperimen menggunakan pendekatan satu kelompok pretest-posttest, yang melibatkan 35 siswa berusia 8 hingga 12 tahun. Pengumpulan data dilakukan melalui tes kinerja keterampilan motorik, kemudian dianalisis menggunakan statistik deskriptif, uji normalitas Shapiro-Wilk, uji t berpasangan, serta analisis N-Gain. Hasil penelitian menunjukkan adanya peningkatan yang signifikan secara statistik antara skor pre-test dan post-test ($p < .001$), dengan ukuran efek yang tergolong sangat besar (Cohen's $d = -3,643$). Temuan ini mengindikasikan bahwa intervensi yang diberikan mampu menghasilkan perubahan yang nyata. Namun, apabila ditinjau dari tingkat peningkatan hasil belajar menggunakan analisis N-Gain, diperoleh nilai rata-rata sebesar 0,164 yang masih berada pada kategori rendah. Hal ini menunjukkan bahwa meskipun terjadi peningkatan secara statistik, dampak praktis dari intervensi tersebut belum sepenuhnya optimal. Temuan ini mengisyaratkan bahwa penggunaan media digital memang mampu meningkatkan keterlibatan siswa dan memberikan pengaruh positif terhadap proses pembelajaran. Dengan demikian, media pembelajaran digital memiliki potensi besar sebagai alat pendukung dalam pendidikan jasmani, namun penggunaannya perlu dirancang secara lebih matang agar dapat memberikan dampak yang maksimal. Secara keseluruhan, studi ini memberikan kontribusi terhadap pengayaan literatur terkait integrasi teknologi dalam pendidikan jasmani, sekaligus membuka peluang bagi pengembangan inovasi pedagogis yang lebih adaptif di masa mendatang.

Kata Kunci: media pembelajaran digital, keterampilan lokomotor, pendidikan jasmani, permainan edukatif.

Abstract: Amid the rapid development of the digital era, the integration of technology in education has become an inevitable necessity, especially to adjust to the characteristics and expectations of today's students. Nevertheless, the use of digital learning media in physical education, particularly in teaching basic locomotor movement skills such as walking, running, and jumping, is still not optimal and tends to be limited. This study aims to examine the extent of the effectiveness of using mobile-based educational games in improving elementary school students' locomotor skills. The research was conducted with a pre-experimental design using a one-group pretest-posttest approach, involving 35 students aged 8 to 12 years. Data collection was carried out through motor skills performance tests, then analyzed using descriptive statistics, Shapiro-Wilk normality test, paired t-test, and N-Gain analysis. The research results showed a statistically significant increase between pre-test and post-test scores ($p < .001$), with an effect size considered very large (Cohen's $d = -3.643$). These findings indicate that the intervention provided was able to produce a substantial change. However, when viewed from the level of learning improvement using N-Gain analysis, the average value obtained was 0.164, which is still in the low category. This indicates that although there was a statistical increase, the practical impact of the intervention has not been fully optimal. These findings suggest that the use of digital media can indeed enhance student engagement and positively influence the learning process. Therefore, digital learning media has great potential as a supporting tool in physical education, but its use needs to be more carefully designed to provide the maximum impact. Overall, this study contributes to the enrichment of literature related to the integration of technology in physical education, while also opening opportunities for the development of more adaptive pedagogical innovations in the future.



Keywords: *digital learning media, locomotor skills, physical education, educational game*

How to Cite: Ockta, Y., Umar, Mardesia, P., Nazaruddin, M. N., & Sabillah, M. I. (2026). Effectiveness of digital learning media in teaching locomotor movements to elementary student. *Jurnal Pendidikan Jasmani Indonesia*, 22(1), 105-114.
<https://doi.org/10.21831/jpji.v22i1.92777>



INTRODUCTION

In the modern educational landscape, the integration of technology has significantly transformed how subjects are taught and learned (Alam & Mohanty, 2023; Ghory & Ghafory, 2021; Makda, 2024). Despite the rapid integration of digital technology in various fields of education, its implementation in basic locomotor movement learning such as walking, running, jumping, skipping, and hopping is still limited and has not received much attention in research (Edriss et al., 2024; Korkut & Surer, 2023). Locomotor movement skills are a fundamental component in the early stages of a child's physical development, which not only serve as a foundation for mastering advanced motor skills, but also contribute to the development of coordination, balance, and spatial awareness (Escolano-Pérez et al., 2021; Lovell et al., 2023). Until now, learning locomotor movements at the elementary school level still relies heavily on conventional approaches, where the teacher acts as a demonstrator of movements, while students follow and imitate directly at the same time (Fogliata et al., 2025; Liu et al., 2025). Although this approach has contributed to the development of basic motor skills, its limitation lies in the lack of interactive elements and active involvement, which potentially hinders the achievement of a more comprehensive understanding as well as the optimization of students' learning motivation (Aloizou et al., 2024). Children who grow up in today's digital age tend to be more familiar with interactive media-based learning, which in turn can provide a more engaging and meaningful learning experience, including in physical education learning (Goodyear et al., 2023; Jastrow et al., 2022).

Digital learning media, which includes instructional videos, animations, motion-capture technology, as well as interactive applications, offers a more visual, dynamic, and engaging approach in the process of learning locomotor movements, thereby potentially increasing the effectiveness of material delivery (Reuter & Schindler, 2023). Unlike conventional methods, digital media can provide instant feedback, present visual demonstrations, and offer gamified learning experiences, thus being more capable of attracting students' interest (Nieto-Escamez & Roldán-Tapia, 2021; Peláez & Solano, 2023; Zhang & Hashim, 2025). For illustration, the use of animated videos or motion-capture-based applications allows children to observe the mechanics of movements such as running or jumping in slow motion display, making it easier to identify appropriate aspects of posture, timing, and technique (Zhao et al., 2021). The use of technology in the world of education has become the focus of various studies, especially in academic fields such as mathematics, science, and language (Alabdulaziz, 2021; Martinez et al., 2022; Ziatdinov & Valles, 2022). Until now, studies on the effectiveness of using digital technology in physical education, particularly for the development of locomotor skills, are still relatively limited. This gap is quite concerning, because the integration of technology can actually open up new opportunities to improve the quality of learning as well as student learning outcomes that are more relevant to classroom conditions in the digital era.

Therefore, it is important to examine the role of digital learning media in teaching locomotor movements to elementary school students. This is inseparable from the fact that today's children grow up in an environment very close to technology and have become accustomed to using devices such as smartphones, tablets, and computers from an early age (Charan et al., 2024). This condition causes the level of student interest and engagement in traditional learning methods to be relatively lower compared to previous generations. In this regard, digital media can be a solution to bridge this gap by providing a more engaging and relevant learning experience, including in physical education. Furthermore, the use of digital technology in locomotor movement learning can also help overcome various obstacles that often arise in conventional methods. For example, a large number of students or limited practice space often makes it difficult for teachers to give optimal attention to each individual. (Habla & Muller, 2021). The use of digital learning media allows for a more flexible learning process, where students can adjust

their own learning pace and review material that has not been understood (Barua & Lockee, 2024; Wong & Hughes, 2023). In addition to providing flexibility, the use of digital technology also allows for real-time feedback, which helps students identify and correct mistakes more efficiently compared to conventional approaches. Furthermore, digital media expands the learning space by enabling students to remain engaged in the learning process outside the formal classroom environment. Various digital platforms and applications have now introduced interactive gamification-based features that allow students to practice locomotor skills independently at home. This approach not only helps strengthen movement mastery but also encourages the continuity of physical activity outside the formal learning environment. However, empirical studies that specifically highlight the effectiveness of mobile-based educational games in improving basic locomotor skills are still relatively limited, especially when viewed in the context of learning in elementary schools in developing countries such as Indonesia. Most previous studies have tended to focus on the use of digital technology in general, without delving deeply into how structured game-based applications can contribute to the development of motor skills. Based on this gap, this study aims to evaluate the effectiveness of mobile-based educational games in enhancing the locomotor skills of elementary school students, while also examining the level of student engagement and motivation during the learning process. The selection of elementary school students as subjects is based on the importance of this phase as a crucial stage in the development of basic motor skills, which serves as the foundation for the development of more complex physical activities later on.

METHODS

This study used a pre-experimental design with a one-group pretest–posttest model to assess the effectiveness of digital learning media in improving students' locomotor skills. Changes in ability were observed through comparisons before and after the intervention, without involving a control group for comparison. This study utilized a digital educational game designed to teach basic locomotor movements to elementary school students. The platform is equipped with an interactive main menu, engaging educational content, quizzes and puzzles, and colorful animations to maintain students' learning interest. Developed using HTML5 technology, the application can be accessed on various devices, making it flexible and easy to use. For public users, the application must be installed independently by downloading and installing the Android Package Kit (APK) file on their devices before use. The combination of interactive features and a game-based learning approach is intended to increase student engagement while supporting the development of motor skills.

This study used purposive sampling involving 35 elementary school students aged 8–12 years who represented classroom conditions with a balanced gender composition. The students underwent a pre-test, digital-based learning intervention, and post-test to assess improvements in locomotor skills, including running, coordination, balance, and agility.

The intervention was carried out for 4 weeks, three times a week, with a duration of 15–20 minutes per session in physical education learning under the supervision of teachers and researchers. The mobile-based games included structured activities to train locomotor movements, such as running in place, jumping, and coordination.

To assess the effectiveness of the intervention, quantitative data were collected through standardized tests measuring locomotor skills and their supporting components, including the 4 × 10 meter shuttle run (agility), throw-catch test (coordination), standing positional balance test (balance), and 30-meter sprint (speed). All tests were conducted according to normative procedures. The research stages included preparation, pre-test, intervention, post-test, and statistical data analysis.

Data were analyzed using descriptive statistics to obtain the mean and standard deviation. Normality tests were conducted using the Shapiro-Wilk method, while the differences between pre-test and post-test scores were analyzed using the paired sample t-test. N-Gain analysis was used to measure the magnitude of the improvement in students' locomotor skills.

Table 1. Effectiveness Categories Based on N-Gain

Effectiveness Category	N-Gain Range
High Effectiveness	$N\text{-Gain} \geq 0.7$
Medium Effectiveness	$0.3 \leq N\text{-Gain} < 0.7$
Low Effectiveness	$N\text{-Gain} < 0.3$

RESULT AND DISCUSSION

Results

This study aims to assess the effectiveness of mobile-based educational games in improving the locomotor skills of elementary school students. The analysis consisted of descriptive statistics, paired samples t-test, assumption checks (normality test), and N-Gain analysis.

Game Platform

This study utilized a digital educational game designed to teach basic locomotor movements to elementary students. The platform used is equipped with an interactive main menu, engaging educational content, quizzes and puzzles, as well as colorful animations to maintain students' learning interest. Developed using HTML5, this platform can be accessed through various devices, making it easy to use quickly and flexibly. The combination of interactive features and a game-based learning approach is designed to increase student engagement while supporting the development of motor skills. The next section presents the results of statistical analysis to evaluate the effectiveness of the interventions conducted. For more information, see Figure 1 below.

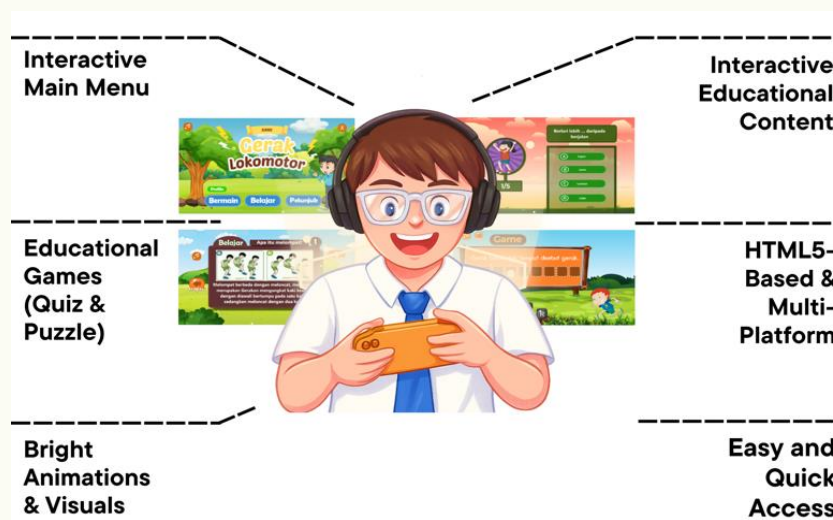


Figure 1. Game Platform

Figure 1 presents the mobile-based educational game platform developed to support the learning of basic locomotor skills among elementary school students. The application, named “**Game Edukasi Gerak Lokomotor**”, was developed using HTML5 technology and is distributed as an Android Package Kit (APK). The application is freely accessible to the public and can be downloaded through Google Drive via the following link: <https://bit.ly/AppLocomotor>. Users can install the application by downloading the APK file, enabling installation from unknown sources on their Android devices if required, and following the on-screen instructions. The platform includes interactive menus, instructional videos, visual animations, educational games, quizzes, and puzzles designed to facilitate independent and enjoyable learning experiences. Because the application can be accessed on various Android devices without requiring paid subscriptions or registration, it provides a flexible and practical learning resource for teachers, students, and the broader community interested in developing basic locomotor movement skills.

Descriptive Statistics

Descriptive statistics are used to provide an overview of student performance before and after the intervention. Table 2 presents the number of valid participants, as well as the mean, standard error, standard deviation, and score range for the pre-test, post-test, and N-Gain results. This table highlights the average improvement in scores and allows initial insights into the effectiveness of the digital learning media.

Table 2. Descriptive Statistics of Pre-Test, Post-Test, and N-Gain

Measurement	N Valid	Mean	Std. Error	Std. Deviation	Min	Max
Pre-Test	35	49.094	1.018	6.021	40.410	59.400
Post-Test	35	57.375	1.038	6.142	47.326	68.498
N-Gain	35	0.164	0.008	0.046	0.079	0.248

The average post-test score ($M = 57.375$) is significantly higher than the pre-test score ($M = 49.094$), indicating learning improvement. However, the N-Gain average (0.164) falls under the “Low Effectiveness” category based on the N-Gain scale.

Normality Test

To validate the assumptions for the t-test, the normality of the post-test data was assessed using the Shapiro-Wilk test, can be seen in Table 3. Then, to further confirm the normality of the data distribution, a Q-Q (Quantile-Quantile) plot was generated. The plot compares the standardized residuals of the post-test scores to the theoretical quantiles of a normal distribution. As shown in Figure 2, the data points closely follow the diagonal reference line, indicating that the residuals are normally distributed.

Table 3. Shapiro-Wilk Normality Test

Variable	W	p-value
Pre-Test & Post-Test	0.974	0.573

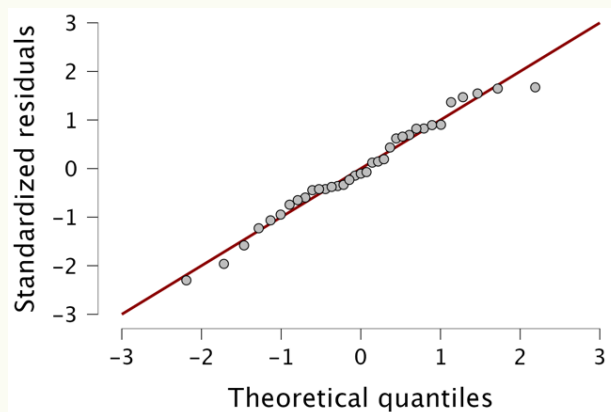


Figure 2. Q-Q (Quantile-Quantile) plot

The near-linear pattern of the points supports the result of the Shapiro-Wilk test ($p = 0.573$), which also indicated that the data did not significantly deviate from normality. Therefore, the assumption of normality required for parametric testing, such as the paired sample t-test, is satisfied.

Paired Samples T-Test

To determine whether the observed improvement in student scores was statistically significant, a paired samples t-test was conducted. Table 4. summarizes the t-test results, including the t-value, degrees of freedom, p-value, and effect size. To visually illustrate the improvement in students' performance, a bar chart comparing the mean scores of the pre-test and post-test was created, as shown in Figure 3. The graph shows a clear increase in the average post-test scores compared to the pre-test.

Table 4. Paired Samples T-Test

Test Pair	t	df	p-value	Mean Difference	SE Diff.	Cohen's d	SE d
Pre-Test & Post-Test	-21.551	34	< .001	-8.281	0,26666667	-3.643	0,12083333

The results showed a significant increase ($p < .001$) with a very large effect (Cohen's $d = -3.643$), which confirms the effectiveness of the digital intervention.

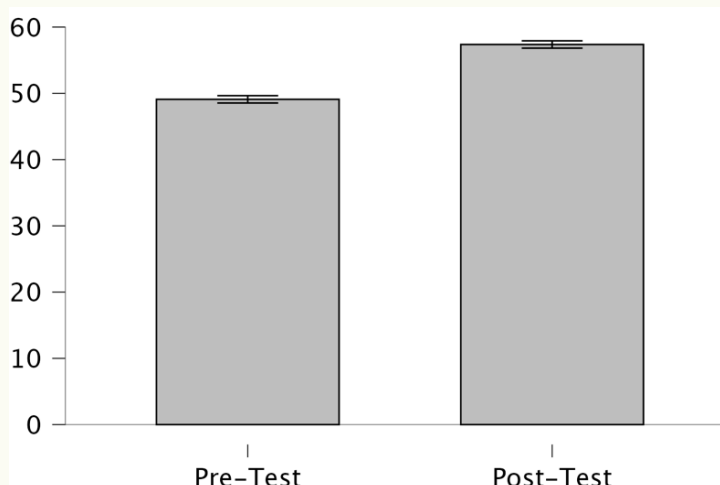


Figure 3. Comparison Between Pre-Test and Post-Test

The average score increased from 49.09 to 57.38, with small and consistent error bars indicating data stability. These results support the statistical analysis confirming the positive influence of digital learning media on students' locomotor skills.

Individual N-Gain Score Analysis

To observe the improvement in each student's learning outcomes, a comparative graph is presented showing the pre-test scores, post-test scores, and N-Gain values. In Figure 4, the bar chart shows the pre-test scores (blue) and post-test scores (red) of 35 students, while the green line represents the N-Gain values of each.

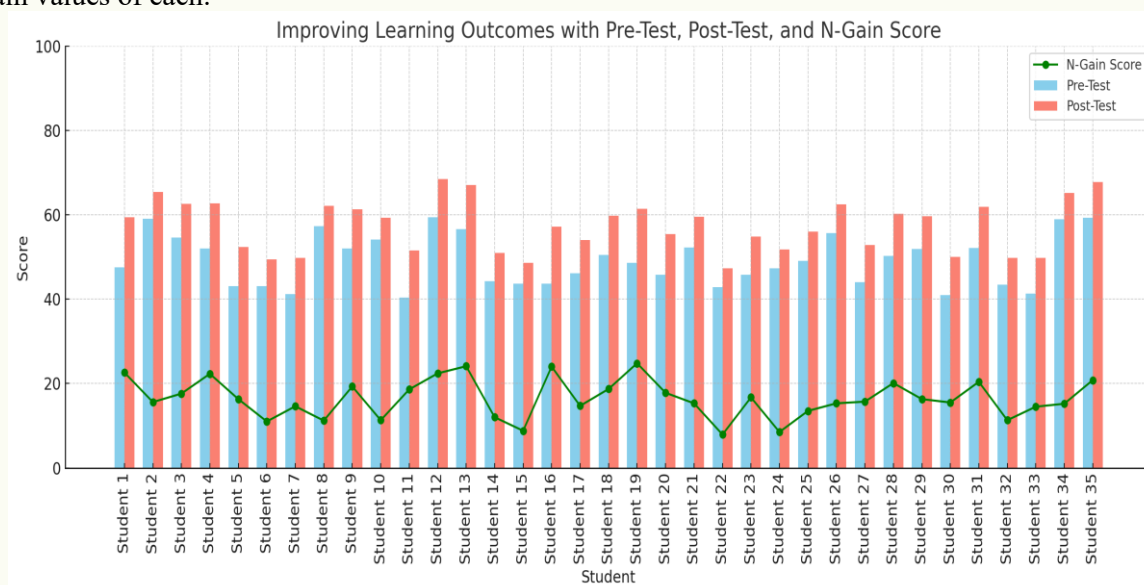


Figure 4. Improving Learning Outcome

The graph shows that all students experienced an increase in post-test scores compared to the pre-test, although the rate of improvement varied. Most of the N-Gain scores fall into the low to medium category, in line with the average N-Gain of 0.164. These findings indicate that digital learning interventions have a positive impact at the individual level, although the average increase achieved is still considered moderate.

Discussion

This research was conducted in response to the increasing need to integrate technology into physical education, specifically in the learning of basic locomotor movements in elementary schools. Skills such as walking, running, jumping, and hopping are important foundations for children's physical development as well as a basis for mastering more complex motor activities. However, the learning of these skills is still dominated by conventional methods, which are considered less aligned with the characteristics of students in the digital era. Therefore, the use of digital learning media such as educational games and interactive platforms becomes an innovative alternative that has the potential to improve student motivation as well as learning outcomes.

The results of this study showed a statistically significant increase in post-test scores compared to pre-test scores, with a very large effect size (Cohen's $d = -3.643$), indicating that the intervention had a strong impact on, such as the research conducted by Chang et al (2020) Previous research examined the application of augmented reality (AR) in enhancing the development of motor skills in early childhood education. The results of that study showed that AR technology is capable of helping the understanding of movement dynamics while also increasing student motivation and engagement. These findings align with this study, which emphasizes the importance of interactive and visual aspects in digital media to enhance student engagement compared to conventional methods. Additionally, the interactive visualization and simulation found in mobile games in this study share a similar mechanism with AR technology, namely helping to concretize abstract movement concepts so that they are easier for students to understand. Another relevant study by Gholami Amin (2022) examines the influence of gamification-based learning platforms on the development of children's motor skills. Mohammad & Boushehry (2023). Several studies indicate that although digital media has advantages in flexibility and visual support, its effectiveness can be limited if students are not accustomed to using technology or when the content has not been optimally integrated with learning objectives (Alenezi et al., 2023). The relatively low average N-Gain score (0.164) indicates that although students demonstrated statistically significant improvements in locomotor skills, the magnitude of practical improvement remained limited. This finding suggests that digital learning media may facilitate initial engagement and understanding of movement concepts but may not be sufficient to produce substantial motor skill development within a short intervention period. Similar findings have been reported in previous studies, which suggest that improvements in motor competence generally require prolonged and repeated practice opportunities to achieve meaningful learning gains (Wen & Wu, 2025). Therefore, the short duration of intervention in this study may partially explain why the observed gains remained within the low effectiveness category (Mølmen et al., 2025).

Another important finding is that the mobile-based educational game appeared to increase students' engagement and participation during learning activities. The interactive menus, colorful animations, quizzes, and game elements provided students with an enjoyable learning environment that encouraged active participation. This result is consistent with gamification theory, which emphasizes that digital game elements can stimulate intrinsic motivation, maintain attention, and increase learning persistence (Dah et al., 2023). In physical education settings, increased engagement is particularly important because positive learning experiences can foster students' willingness to participate in physical activities and develop healthy movement habits from an early age (Martín-Rodríguez & Madrigal-Cerezo, 2025).

Furthermore, the flexibility of the platform also contributed to its educational value. Since the application was developed using HTML5 and distributed through an Android Package Kit (APK), students could install the application independently and access learning materials outside the classroom environment. This accessibility potentially extends learning opportunities beyond formal instructional time and encourages autonomous practice. Previous studies have demonstrated that technology-supported learning environments that provide flexibility and self-paced learning opportunities can

enhance students' sense of autonomy and facilitate knowledge retention (Nikolopoulou, 2023; Yorganci, 2026). In the context of physical education, the opportunity to repeatedly observe movement demonstrations and practice independently may reinforce students' understanding of locomotor techniques and gradually improve motor performance.

In addition, media design that does not adjust to the students' skill levels can also affect the outcomes achieved. Practically, these findings reinforce that digital learning media should be used as a complement, not a replacement, to conventional methods. The role of the teacher remains important in guiding and correcting movements, while digital media functions to reinforce learning through visualization, repetition, and game-based approaches. This study has limitations, including a small sample size, a short intervention duration, and the fact that the ease of use of the media has not yet been analyzed. Therefore, future research is recommended to involve a more diverse sample, a longer duration, and a more comprehensive approach. Overall, digital learning media has been shown to increase student engagement and performance, although the level of improvement is still moderate.

CONCLUSION

This study shows that mobile-based digital learning media is capable of significantly improving students' gross motor skills, with a large effect size. However, the relatively low N-Gain value indicates that the level of improvement achieved is not yet fully optimal. On the other hand, the use of digital media has been proven effective in increasing student engagement as well as providing a more interactive and attractive learning experience. Therefore, its use is more appropriate as a support for conventional learning, rather than as a primary replacement. For further development, it is recommended to use a stronger research design, a longer intervention duration, and a larger sample size in order to obtain more comprehensive results. Overall, this study provides empirical contributions to the development of technology integration in physical education, while also opening up opportunities for learning innovations in the development of motor skills in the future.

ACKNOWLEDGMENT

The researcher expresses gratitude to all parties who have contributed to this research.

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