

The Effectiveness of Exergaming in Improving Locomotor Skills in Kindergarten Learners

ABSTRACT

This action research examined the effectiveness of exergaming in improving locomotor skills among kindergarten learners at Carmen Elementary School in Davao Oriental. Grounded in Fitts and Posner's Cognitive Theory of Motor Learning, which delineates the cognitive, associative, and autonomous stages of skill development, the study aimed to evaluate how digital, game-based movement activities enhanced fundamental locomotor movements such as walking, running, hopping, skipping, and jumping. Employing a one-group pre-test–post-test experimental design involving 15 kindergarten learners, the intervention consisted of five structured exergaming sessions. Learners' locomotor performances were assessed using a validated, researcher-developed rubric, and quantitative data were analyzed using means, paired t-tests, and Cohen's d to measure effect size. Results revealed a significant increase in post-test mean scores ($M = 12.45$, $SD = 0.75$) compared to pre-test scores ($M = 7.56$, $SD = 0.61$), with the paired t-test yielding a statistically significant difference ($t = 20.344$, $p = 0.001$) and a Cohen's d value of 5.253 indicating a very large effect size. These findings confirmed that exergaming has a powerful impact on the development of locomotor skills in early learners, supporting its use as a highly engaging and developmentally appropriate strategy for enhancing physical education in kindergarten.

Keywords: Exergaming, Locomotor Skills, Kindergarten Learners, Cognitive Theory of Motor Learning, Physical Education

1. INTRODUCTION

Physical education is a part of the K to 12 school curriculum in the Philippines, which involves the compulsory teaching and learning of physical education (DepEd, 2016) aimed at contributing to the total growth and development of all children. Moreover, in most instructional programs, it is the only component that addresses all learning domains: psychomotor, cognitive, and affective (Pangrazi, R. P., & Beighle, A., 2019). Furthermore, the purpose of Physical Education is not only for students to develop motor skills but also cognitive, social, and affective skills (Posso-Pacheco et al., 2020). Through this, students develop their own active and healthy lifestyles by acquiring knowledge and engaging in physical activities such as body movement, coordination, play, sports, and physical activity (Rovira-Fon, M., & Vilanova-Soler, A., 2022).

In terms of development, locomotor skills emerge during early childhood and are influenced by both maturation and environmental interactions (Foweather et al., 2021). However, most children require structured instruction and guided experiences to master complex physical skills (Rudd et al., 2015). Toddlers and preschoolers benefit from environments that offer frequent opportunities to practice foundational movements such as walking, running, and jumping (Sutapa et al., 2021). By the age of one, many children start walking independently, and by age four, they typically develop the ability to run, hop, and jump (Foweather et al., 2021). As children reach the ages of six to seven years old, more complex locomotor skills, such as skipping, galloping, and leaping, generally emerge with adequate developmental support (Rudd et al., 2015). These competencies are essential for

efficient movement and contribute to children's physical competence and long-term active lifestyles (Sutapa et al., 2021).

Nevertheless, in Medan, Indonesia, some children may struggle to perform basic locomotor movements, which can hinder their developmental progress (Dewi & Verawati, 2022). This challenge is often linked to the habitual use of gadgets by parents as a means to pacify their children, which has been shown to have an adverse effect on psychomotor development (Fatmawati, 2023). Furthermore, many elementary school teachers demonstrate limited awareness and understanding of the full spectrum of locomotor skills, often focusing only on basic actions such as walking, running, and jumping, resulting in the frequent neglect of more complex movements like hopping, galloping, sliding, skipping, and leaping in early education settings (Dewi & Verawati, 2022). This situation is further exacerbated by structural barriers such as a lack of subject hours and insufficient sports facilities, which hinder teachers from fully delivering essential physical education content (Purnami & Formen, 2020).

On the other hand, in Mataram, Indonesia, students' movement activities have significantly decreased due to the shift to online learning. This transition has not only altered learning behavior but has also resulted in most activities now being conducted online, with students spending extended periods in front of laptops for schoolwork (Widodo et al., 2020). As a result, children with reduced motor competence are at higher risk of being overweight or obese, which further negatively impacts their motor skills and physical fitness (Rodrigues et al., 2016). Some children still struggle with basic locomotor movements, which may delay their development and minimize their physical activity (Widiarti, 2021).

To address these issues, stimulating basic motor skills is crucial because not all children experience normal movement development, and the basic locomotor abilities they possess are foundational skills that must be mastered according to their age (Utari & Indahwati, 2015). Finco et al. (2015) observed that students who were typically unmotivated in physical education classes showed enthusiasm for exergaming and demonstrated a willingness to collaborate with peers. Although screen-based, exergaming has been shown to promote physical activity among preschool children by enhancing motor skill competence and motivation (Gao et al., 2018). Additionally, exergaming has recently been introduced in school settings as an innovative and engaging method to encourage active lifestyles with positive effects on physical development (Gao et al., 2016).

However, the application of exergaming in rural areas, particularly in Davao Oriental, remains underexplored. Limited access to technology and community-specific challenges continue to hinder the integration of innovative physical education strategies in many underserved regions. In Carmen, a barangay in the municipality of Boston, Davao Oriental, these limitations are particularly evident, highlighting the urgency of localized interventions. Therefore, this research aims to bridge this gap by investigating how exergaming can enhance physical education and promote better motor skill development among kindergarten learners, particularly during the critical ages of three to five years when locomotor and object-control skills emerge and develop.

2. THEORETICAL FRAMEWORK

This study is grounded in Fitts and Posner's Cognitive Theory of Motor Learning, which describes skill acquisition as progressing through three stages: cognitive, associative, and autonomous (Fitts & Posner, 1967). These stages provide a structured understanding of how learners develop and refine motor skills, highlighting the cognitive demands and practice requirements at each level (Shaw, 2020). The theory is particularly applicable to developing locomotor skills such as walking, running, and jumping, as it mirrors the natural progression from novice learning to skilled performance (Fitts & Posner, 1967; Shaw, 2020).

In the Cognitive Stage, learners primarily focus on understanding the mechanics of the task and forming a mental blueprint of the movements involved (Fitts & Posner, 1967).

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This stage is characterized by inconsistency and conscious effort, as learners rely on instruction, observation, and feedback to identify correct patterns (Shaw, 2020). Shaw (2020) emphasizes that simplified instructions and controlled environments are crucial for avoiding cognitive overload during this early stage. In exergaming, visual cues and interactive guidance facilitate an understanding of basic movements, such as jumping (Shaw, 2020).

The Associative Stage marks a transition to refining movement patterns and improving consistency and efficiency (Fitts & Posner, 1967). Learners in this stage rely more on self-correction and less on external feedback, shifting focus from "what to do" to "how to do it" (Shaw, 2020). According to Shaw (2020), this phase also involves integrating environmental stimuli, thereby enhancing timing and coordination. Exergaming environments, such as virtual obstacle navigation or reaction-based challenges, offer repetitive opportunities to strengthen skills like hopping and skipping (Shaw, 2020).

The final Autonomous Stage represents the mastery of motor skills, where execution becomes automatic and adaptable to complex situations (Fitts & Posner, 1967). In this phase, learners demonstrate fluid and efficient movements with minimal conscious effort (Shaw, 2020). Shaw (2020) notes that learners can now redirect attention to external cues or complex tasks without compromising performance. Within exergaming, this may involve seamlessly combining movements such as running and jumping in fast-paced game settings (Shaw, 2020).

3. OBJECTIVES

This research focused on finding the effectiveness of exergaming in improving the locomotor skills of kindergarten learners at Carmen Elementary School. As such, this study aimed to:

1. Determine the level of pre-test scores in terms of locomotor skills among kindergarten learners at Carmen Elementary School.
2. Determine the level of post-test scores in terms of locomotor skills among kindergarten learners at Carmen Elementary School.
3. Determine the significant difference between the pre-test and post-test results of the kindergarten learners at Carmen Elementary School.

4. MATERIALS AND METHODS

Research Design

This study employed an experimental research design, a scientific approach that involves manipulating an independent variable while controlling for external factors to observe its effect on a dependent variable.

The researchers employed this design to determine the causal relationship between the exergaming intervention (independent variable) and the improvement of locomotor skills (dependent variable) among kindergarten learners. This approach was appropriate for controlled educational settings, where the implementation and adjustment of variables were both feasible and ethically sound.

The study employed a pretest-posttest design, utilizing a standardized, performance-based rubric to assess skill development. A total of 15 kindergarten learners from Carmen Elementary School participated in the intervention, which was conducted through tutorial classes over five sessions. The design enabled the collection of empirical evidence to support claims regarding the effectiveness of exergaming on early motor skill development.

Research Instrument

The research instruments utilized in this study included an assessment rubric for locomotor skills, specifically designed to evaluate kindergarten learners' locomotor skills before and after the exergaming intervention. This rubric focused on critical locomotor skills such as running, jumping, and skipping, and aligned with the learning competency: "demonstrate locomotor and non-locomotor movements," with an exclusive focus on locomotor skills.

The rubric featured performance criteria that categorized learner performance into five levels: Excellent, Very Satisfactory, Satisfactory, Needs Improvement, and Poor. This structure enabled an objective evaluation of each learner's progress, allowing for a clear identification of areas for improvement or mastery.

The study employed a researcher-developed rubric assessment tool to measure respondents' proficiency in hopping, jumping, running, skipping, and walking. To ensure content validity, three experts evaluated the rubrics, focusing on the relevance of the indicators, alignment with the constructs, and overall precision of the instrument. Their assessments yielded an Aiken's V coefficient of 0.89, indicating excellent validity. Furthermore, the tool was pilot-tested to establish inter-rater reliability, with Kendall's coefficient of concordance calculated at 0.417, demonstrating the instrument's reliability (Schmidt, 1997). These procedures confirmed the tool's validity and reliability for assessing the specified skills.

Respondents of the Study

The respondents of this study were 15 kindergarten learners enrolled at Carmen Elementary School. The respondents were selected using an experimental sampling method, and the intervention was conducted through tutorial classes. All selected learners participated in the exergaming intervention, which aimed to improve their locomotor skills through guided physical activities.

A self-made performance-based rubric was used to assess locomotor skills during the pre-test and post-test. Only those who completed both assessments were included in the final data analysis. To ensure the validity and reliability of the results, any learner who was absent during the post-test was excluded, even if they had completed the pre-test.

Data Gathering

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The research followed a data gathering procedure that consisted of several steps:

1. **Ethical Clearance Acquisition:** The researchers obtained ethical clearance from the University Research Ethics Board (UREB). This step ensured compliance with ethical guidelines and safeguarded the rights of participants.
2. **Permission Request:** After receiving ethical approval, the researchers requested permission from the school principal and relevant authorities at Carmen Elementary School. This request detailed the study's purpose, participant involvement, and data collection methods, ensuring transparency and collaboration with the school administration.
3. **Parental Assent Letters:** Parents or guardians received letters explaining the study's purpose and activities involved. These letters confirmed that participation was voluntary and requested written consent for their child's involvement.
4. **Pre-Test Administration:** The researchers administered a pre-test to assess the learners' initial locomotor skills, such as running, jumping, and skipping. This served as a baseline measurement prior to the intervention.
5. **Experimental Group Implementation:** The experimental group engaged in exergaming activities designed to improve their locomotor skills. These activities were specifically tailored to enhance the learners' running, jumping, and skipping abilities.
6. **Post-Test Administration:** After the intervention period, a post-test assessment was conducted for both groups to measure improvements in locomotor skills.

5. RESULTS AND DISCUSSION

This chapter presents the results and discussion of the study. The discussion is organized according to the statements of the problem. It includes the corresponding analysis and interpretation of the data.

Level of Pre-test Scores

Table 1 presents the pre-test scores in locomotor skills among kindergarten learners before the implementation of the exergaming intervention. The results show that learners obtained a total score of 15, with a mean of 7.56 and a standard deviation of 0.61. This is equivalent to a transmuted grade of 72, which is interpreted as "Did Not Meet Expectations." According to the Department of Education's MATATAG Curriculum (DepEd, 2022), this grade reflects that learners have not yet achieved the minimum standard competency in physical education, particularly in executing foundational locomotor movements such as walking, hopping, and skipping.

Table 1. Level of Pre-Test.

Variable	Total Score	Mean	Std. Deviation	Transmuted Grade	Interpretation
Pre-Test	15	7.56	0.61	72	Did Not Meet Expectation

These low initial scores underscore the need for intervention programs to help learners acquire the required motor competencies (Stiano et al., 2022). The observed lack of structured support in many early learning environments underscores the urgent need for targeted interventions to promote motor skill development in early childhood (Zhao et al., 2024). Similarly, Oppici et al. (2022) highlighted that children entering structured physical activity programs often have limited foundational movement skills, especially in underserved or inactive populations. Likewise, Liu et al. (2020) concluded that learners with limited motor experiences prior to school-based interventions tend to perform poorly in fundamental

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movement assessments. This underperformance supports the premise that additional support and developmentally appropriate movement exposure are necessary during early education.

Similar to Gao et al. (2018), the pre-test results in this study indicate low motor skill competence among preschoolers, with motor skill competence improving only following the exergaming intervention. Echoing Liu et al. (2020), baseline locomotor skills in young learners are often below expectations, frequently requiring targeted intervention to achieve mastery levels. Likewise, Lindsay et al. (2020) found that preschoolers had low pre-intervention movement skill levels, which only improved after structured and guided practice, supporting the deficiencies observed in the present study's pre-test outcomes.

Two factors may have contributed to the low pre-test performance. First, the prevalence of sedentary behavior among young learners restricts physical skill development (Gao et al., 2015). Excessive screen time and limited opportunities for movement activities reduce children's motor learning potential (Zeng & Gao, 2016). Second, the absence of structured real-world movement experiences has a negative impact on biomechanical development (Goodway et al., 2019). Children need repeated, age-appropriate physical engagements to foster motor competence, yet many do not receive these experiences at home or in under-resourced schools (Bakhtiar et al., 2019).

Level of Post-Test Scores

Table 2 presents the post-test scores of kindergarten learners in locomotor skills after undergoing the exergaming intervention. The learners achieved a total score of 15, with a mean of 12.45 and a standard deviation of 0.75. This corresponds to a transmuted grade of 89, which falls under the "Very Satisfactory" category.

Table 2. Level of Post-Test Scores

Variable	Total Score	Mean	Std. Deviation	Transmuted Grade	Interpretation
Post-Test	15	12.45	0.75	89	Very Satisfactory

The post-test results indicate substantial improvements in the learners' locomotor skill performance. According to the Department of Education's grading scale (DepEd Order No. 8, s. 2015), this level of performance indicates that learners consistently demonstrate mastery of movement skills appropriate for their age. This improvement underscores the success of the exergaming intervention in promoting physical development in early childhood.

These findings align with the results of Gao et al. (2019), who found that an 8-week structured exergaming program significantly improved the motor skill competence of preschoolers. Similarly, Oppici et al. (2022) conducted a meta-analysis, confirming that exergaming interventions consistently led to meaningful gains in fundamental movement skills among children aged 3–12 years. Additionally, McGann et al. (2019) reported that exergaming interventions significantly enhanced locomotor skills, such as hopping, running, and jumping, when integrated into classroom settings with consistent structure.

Further support for these outcomes comes from Hassan et al. (2022), who reported that exergaming produced the most substantial improvement in locomotor skills among physical activity interventions, yielding a standardized mean difference (SMD) of 12.50. These findings highlight the effectiveness of exergaming as a developmentally appropriate and engaging approach for enhancing motor competence in early childhood settings.

The results also reflect the learning progression outlined in Fitts and Posner's Cognitive Theory of Motor Learning. This theory posits that learners progress through cognitive, associative, and autonomous stages in the acquisition of skills. During the

exergaming intervention, learners first understood the movement tasks (cognitive stage), practiced and refined them (associative stage), and eventually demonstrated smooth execution (autonomous stage). As Zhao et al. (2024) explained, when exergaming is implemented in short, structured sessions with teacher support, it becomes an effective tool for enhancing early physical education outcomes aligned with cognitive development.

Difference Between Pre-test and Post-test Scores

Table 3 presents the results comparing the pre-test and post-test scores of kindergarten learners in terms of their locomotor skills following the exergaming intervention. The mean score increased from 7.56 in the pre-test to 12.45 in the post-test, with standard deviations of 0.61 and 0.75, respectively. The computed t-value of 20.344 and a p-value of 0.001 indicate a statistically significant difference between the two assessments. Additionally, the calculated Cohen's d coefficient was 5.253, signifying a very large effect size. This confirms that the exergaming intervention had a strong and meaningful impact on improving the locomotor skills of the learners (DepEd Order No. 8, s. 2015).

Table 3. Mean comparison between pre-test and post-test scores

Variables	Mean	Standard Deviation	t-value	degrees of freedom (df)	p-value	Cohen's d Coefficient
Pre-test	7.56	0.61	20.344	14	0.001	5.253
Post-test	12.45	0.75				

The results show a clear and substantial improvement in the learners' locomotor performance after engaging in the exergaming activities, confirming the effectiveness of the intervention and highlighting how learners progressed from below-expectation performance levels to competent movement execution (McGann et al., 2019; Hassan et al., 2022). The large effect size suggests that the change was not due to chance but a result of the exergaming experience, reinforcing the importance of integrating interactive and developmentally appropriate movement-based interventions in kindergarten physical education (Trost & Brookes, 2021; Chen et al., 2024).

These findings are supported by McGann et al. (2019), who demonstrated that purpose-built exergames significantly enhanced locomotor skill performance in children, particularly when implemented with a structured design. Similarly, Hassan et al. (2022) emphasized that exergaming yielded the strongest effect among physical activity interventions for locomotor development (SMD = 12.50), validating the large impact observed in this study. Both studies highlight the effectiveness of well-planned digital movement games in promoting noticeable improvements in the motor skills of young learners (McGann et al., 2019; Hassan et al., 2022).

The findings are also consistent with the study by Trost and Brookes (2021), which conducted an RCT using a digital app and found significant gains in locomotor skills among preschoolers compared to control groups. Furthermore, Chen et al. (2024) concluded that structured movement interventions are more effective than unstructured ones, showing a standardized mean difference of 0.35 in favor of structured activities. These studies support the strong and consistent impact observed in the present exergaming intervention.

This outcome supports Fitts and Posner's Cognitive Theory of Motor Learning, which states that learners initially process and understand the movement (cognitive stage), then refine their execution through practice (associative stage), and finally perform the skills automatically (autonomous stage). The use of exergaming enabled this progression by

engaging learners through repetitive, interactive, and feedback-rich tasks. As Zhao et al. (2024) noted, exergames can enhance Physical Education outcomes when tailored to learners' needs and delivered with teacher support in short, focused intervals. These results imply that exergaming can serve as an innovative and effective strategy in early childhood education to close developmental gaps in motor skills.

The Implications for Physical Education

This study aimed to improve the locomotor skills of kindergarten learners through exergaming, using Fitts and Posner's Cognitive Theory of Motor Learning as its theoretical foundation. The results offer insights into how movement-based digital interventions can transform early physical education (PE) into a more engaging, developmental, and skill-oriented experience. The theory emphasizes learning progression from cognitive understanding to automatic performance, which aligns with the structured and repetitive nature of exergames.

Physical education benefits from instructional models that replicate real-life movement demands in safe, motivating environments. Exergaming enables young learners to practice fundamental movements, such as walking, hopping, running, and skipping, while engaging in interactive gameplay that reinforces skill repetition, provides feedback, and fosters enjoyment.

The study suggests the following implications:

1. It supports learner engagement and motivation through game-based tasks. Interactive features such as real-time feedback, visual stimuli, and achievable challenges help sustain learner interest and enthusiasm for physical activity. This aligns with Zhao et al. (2024), who emphasized that short, focused exergaming sessions improve Physical Education learning when tailored to children's developmental levels.
2. It facilitates progression across the stages of motor learning. Exergaming enables learners to comprehend movement mechanics (cognitive stage), refine their skills through repetition (associative stage), and ultimately perform with confidence and fluidity (autonomous stage). According to Lee et al. (2020), structured and teacher-supported interventions contribute significantly to skill mastery in Physical Education.
3. It empowers teachers to implement developmentally appropriate movement instruction. By integrating technology in Physical Education, educators can provide learners with meaningful practice opportunities while maintaining structure and focus. As Chan et al. (2019) noted, guided movement programs are more effective when they include age-appropriate tasks, learner feedback, and consistent teacher facilitation.

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Based on the findings, the following recommendations are made for different stakeholders:

1. To address the currently low level of locomotor skills, schools and early childhood educators can incorporate structured physical activities, such as exergaming, into the kindergarten curriculum. These movement-based games provide an engaging way for learners to meet developmental benchmarks in physical education.

2. Given the effectiveness of the exergaming intervention, school administrators may consider investing in age-appropriate exergaming equipment (e.g., Wii Fit, Xbox Kinect, or tablet-based motion games) and providing teacher training on how to integrate these tools into daily physical education sessions effectively.
3. Based on the significant improvement observed between the pre- and post-test scores, further research is recommended to explore the long-term effects of exergaming on motor development. Future studies with larger sample sizes and extended intervention periods may help determine the sustained impact of exergaming across various early grade levels.

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