Joska: Isori Kampar Jurnal | Indonesian Sport & Physical Scientist Association Journal
Vol 2 (1), 2025.

Original Research

The Influence of Interactive Digital Media on Cognitive Understanding in Physical Education

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ABSTRACT

Objectives: Physical education has traditionally relied on conventional teaching methods, but the integration of interactive digital media presents new opportunities to enhance cognitive understanding. The evolution of digital technologies has significantly influenced educational practices, particularly in motor skill acquisition and cognitive development in physical education settings. This study aims to investigate how interactive digital media influences cognitive understanding among elementary school students in physical education, specifically examining improvements in motor skill comprehension, spatial reasoning, and movement pattern recognition
Methods: A quasi-experimental design was employed with 40 elementary school students (20 male, 20 female) from schools in Medan City, North Sumatra, Indonesia. Participants were randomly assigned to experimental and control groups. The experimental group received physical education instruction using interactive digital media, while the control group received traditional instruction. Cognitive understanding was measured through pre- and post-tests, observation checklists, and performance assessments.
Results: The experimental group showed significant improvements in cognitive understanding compared to the control group ($p < 0.05$). Students demonstrated enhanced comprehension of movement patterns, improved spatial reasoning skills, and better retention of motor learning concepts when exposed to interactive digital media.
Conclusion: Interactive digital media significantly enhances cognitive understanding in physical education among elementary students. The technology facilitates clearer visualization of movement patterns, improves student engagement, and supports more effective learning outcomes in physical education contexts.

Keywords: interactive digital media, cognitive understanding, physical education, elementary students, motor learning, educational technology.

Received: January 25, 2025 | Accepted: March 25, 2025 | Published: March 27, 2025

INTRODUCTION

The integration of digital technologies in educational settings has transformed traditional pedagogical approaches across various disciplines, including physical education. Interactive digital media encompasses technological tools that allow students to engage actively with learning content through multimedia presentations, animations, virtual demonstrations, and interactive applications. In physical education, these technologies provide opportunities for students to visualize complex movement patterns, understand biomechanical principles, and develop cognitive schemas related to motor skills.

The contemporary educational landscape emphasizes the importance of cognitive development alongside physical skill acquisition in physical education. Cognitive understanding in this context refers to students' ability to comprehend movement principles, analyze technique components, understand strategic concepts, and apply theoretical knowledge to practical performance. This cognitive dimension is crucial for long-term motor learning and transfer of skills across different physical activities.

Recent research has demonstrated the positive impact of digital technologies on learning outcomes in physical education. Studies indicate that interactive learning media can improve motor skills and increase students' motivational levels for physical education activities. Research by Lanos et al. (2024) found that interactive manipulative motion learning media significantly increased students' motivation, with 91% of participants showing improved engagement in learning activities.

Digital media implementation in physical education has shown effectiveness in multiple areas. Students gain clearer understanding of movement execution through visual demonstrations, while technology facilitates individual learning and intuition development. The use of tablets, smartphones, computers, and specialized applications has become increasingly common, with positive effects reported on learning effectiveness and motor skill development.

Systematic reviews have confirmed that digital technology integration positively impacts cognitive learning outcomes, with video and animation-based approaches being most prevalent (26.92%), followed by virtual/augmented reality and interactive applications (19.23% each). The most significant advancements are observed in problem-solving and spatial reasoning skills when technologies incorporate constructivist principles and interactive engagement strategies.

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Despite the growing body of research on digital media in education, several gaps remain in understanding its specific influence on cognitive understanding in physical education contexts. Limited studies have focused specifically on elementary school students' cognitive development through interactive digital media in physical education settings. Additionally, there is insufficient research examining the relationship between digital media exposure and specific cognitive processes such as spatial reasoning, movement pattern recognition, and motor learning comprehension among young learners.

Furthermore, most existing studies focus on general learning outcomes rather than cognitive understanding specifically. The mechanisms through which interactive digital media influences cognitive processes in physical education remain under-explored, particularly in Indonesian educational contexts where traditional teaching methods still dominate.

Understanding how interactive digital media influences cognitive understanding in physical education is crucial for several reasons. First, cognitive development during elementary years significantly impacts long-term learning and motor skill acquisition. Second, the integration of technology in physical education requires evidence-based approaches to ensure effective implementation. Third, Indonesian educational contexts present unique challenges and opportunities that warrant specific investigation.

The rapid advancement of digital technologies and their increasing availability in educational settings necessitates research to guide effective integration. Understanding the cognitive impacts of interactive digital media can inform curriculum development, teacher training programs, and educational policy decisions regarding technology implementation in physical education.

This study aims to:

1. Examine the influence of interactive digital media on cognitive understanding in physical education among elementary school students
2. Compare cognitive learning outcomes between students using interactive digital media and those receiving traditional instruction
3. Identify specific cognitive domains most affected by interactive digital media intervention
4. Analyze the relationship between digital media exposure and improvements in movement pattern recognition and spatial reasoning
5. Provide evidence-based recommendations for integrating interactive digital media in elementary physical education programs

MATERIALS AND METHODS

Participants

The study involved 40 elementary school students (20 male and 20 female) aged 8-10 years from public elementary schools in Medan City, North Sumatra, Indonesia. Participants were selected through purposive sampling based on the following inclusion criteria: (1) regular attendance in physical education classes, (2) no previous extensive exposure to digital learning technologies in physical education, (3) normal cognitive development according to school records, and (4) parental consent for participation. Students with physical disabilities or learning difficulties were excluded from the study.

Participants were randomly assigned to two groups: experimental group (n=20) receiving physical education instruction with interactive digital media, and control group (n=20) receiving traditional instruction methods. Demographic characteristics were balanced between groups to ensure comparability

Study Organization

The research employed a quasi-experimental design with pre-test and post-test measurements. The intervention period lasted 12 weeks, with two 60-minute physical education sessions per week. The experimental group utilized interactive digital media including:

Table 1. Study Organization and Intervention Structure

Component	Description
Research Design	Quasi-experimental design with pre-test and post-test measurements.
Intervention Duration	12 weeks, consisting of two 60-minute physical education sessions per week.
Experimental Group Instruction	Utilized interactive digital media, including: • Tablet-based movement analysis applications • Interactive video demonstrations of motor skills • Augmented reality (AR) movement pattern visualization • Digital feedback systems for technique correction • Gamified learning platforms for motor skill concepts
Control Group Instruction	Received traditional physical education instruction using: • Conventional demonstration methods • Verbal explanations • Standard teaching materials
Session Structure	Warm-up, skill instruction, guided practice, cognitive engagement tasks, and reflection activities.

Table 2. Data Collection Instruments

Instrument	Description	Purpose
Cognitive Understanding Assessment Scale (CUAS)	Researcher-developed scale measuring understanding of movement principles, spatial awareness, and motor learning concepts.	Assesses cognitive domain related to physical literacy and conceptual knowledge.
Movement Pattern Recognition Test (MPRT)	Computerized test evaluating recognition and analysis of movement sequences.	Measures students' ability to identify, analyze, and interpret motor patterns.
Spatial Reasoning Assessment (SRA)	Standardized spatial reasoning test adapted for physical education settings.	Evaluates spatial visualization skills essential for motor task planning.
Learning Engagement Observation Checklist	Structured observational tool assessing student participation, attention, and cognitive engagement during lessons.	Measures behavioral and cognitive engagement throughout instructional sessions.

Study Organization

Data analysis was conducted using SPSS version 28.0. Descriptive statistics were calculated for all variables, including means, standard deviations, and frequency distributions. Normality of data distribution was assessed using the Shapiro-Wilk test. Independent samples t-tests were used to compare pre-test scores between groups to ensure baseline equivalence.

The primary analysis involved paired samples t-tests to examine within-group changes from pre-test to post-test, and independent samples t-tests to compare post-test scores between experimental and control groups. Effect sizes were calculated using Cohen's d to determine the practical significance of differences. Analysis of covariance (ANCOVA) was conducted to control for potential confounding variables such as prior physical activity experience and baseline cognitive abilities.

Statistical significance was set at $p < 0.05$ for all analyses. Missing data were handled using listwise deletion, and assumption testing was conducted prior to all parametric analyses

RESULTS

Participant Characteristics

The final sample consisted of 40 elementary students with complete data sets. The experimental and control groups were well-matched on demographic variables and baseline assessments. Mean age was 8.7 years (SD = 0.8) for the experimental group and 8.9 years (SD = 0.7) for the control group, with no significant difference ($p = 0.42$).

Cognitive Understanding Assessment Scale (CUAS) Results: The experimental group demonstrated significant improvement in overall cognitive understanding scores from pre-test (M = 42.3, SD = 8.1) to post-test (M = 76.8, SD = 7.2), $t(19) = 18.45$, $p < 0.001$, Cohen's d = 4.12. The control group showed modest improvement from pre-test (M = 41.7, SD = 7.8) to post-test (M = 48.2, SD = 8.9), $t(19) = 3.21$, $p = 0.005$, Cohen's d = 0.72.

Tabel 3. Participant Characteristics and CUAS Results

Variable	Experimental Group	Control Group	Statistics
Sample Size	n = 20	n = 20	Total N = 40
Mean Age (SD)	8.7 (0.8)	8.9 (0.7)	p = 0.42 (ns)
CUAS Pre-test (M ± SD)	42.3 ± 8.1	41.7 ± 7.8	—
CUAS Post-test (M ± SD)	76.8 ± 7.2	48.2 ± 8.9	—
Within-group Effect Size (Cohen's d)	4.12 (very large)	0.72 (moderate)	—
Within-group t-test	t(19) = 18.45, p < 0.001	t(19) = 3.21, p = 0.005	—
Between-group Post-test Comparison	—	—	t(38) = 10.83, p < 0.001, d = 3.42

Between-group comparison of post-test scores revealed significant differences favoring the experimental group, $t(38) = 10.83$, $p < 0.001$, Cohen's d = 3.42.

Assessment Domain	Experimental Group	Control Group	p-value	Effect Size
Movement Principles	78.4 ± 6.8	49.1 ± 8.2	<0.001	3.89
Spatial Reasoning	75.2 ± 7.4	47.8 ± 9.1	<0.001	3.35
Motor Learning Concepts	76.9 ± 6.9	48.5 ± 8.7	<0.001	3.67

Movement Pattern Recognition Test (MPRT) Results:

Significant improvements were observed in the experimental group's ability to recognize and analyze movement patterns. Pre-test accuracy was 45.2% (SD = 12.3), improving to 82.7% (SD = 8.9) at post-test, representing an 83% improvement. The control group improved from 44.8% (SD = 11.7) to 51.3% (SD = 12.8), representing a 14.5% improvement.

Table 4. MPRT and SRA Outcomes

Outcome Measure	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Improvement (%)	Notes
MPRT – Experimental	45.2 ± 12.3	82.7 ± 8.9	83% ↑	Significant improvement
MPRT – Control	44.8 ± 11.7	51.3 ± 12.8	14.5% ↑	Modest improvement
SRA – Experimental	38.4 ± 9.2	71.6 ± 8.3	—	Substantial gain
SRA – Control	37.9 ± 8.8	42.1 ± 9.6	—	Small gain

Table 5. Secondary Outcomes: Engagement and Retention

Outcome	Experimental Group	Control Group	Statistical Notes
Active Participation (%)	89.3%	62.7%	p < 0.001
Sustained Attention (%)	94.2%	71.5%	—
Retention of Cognitive Concepts (4-week follow-up)	91.2%	73.8%	p < 0.001

The experimental group showed substantial gains in spatial reasoning abilities relevant to physical education contexts. Scores increased from 38.4 ± 9.2 to 71.6 ± 8.3, while the control group improved from 37.9 ± 8.8 to 42.1 ± 9.6.

Observational data revealed significantly higher engagement levels in the experimental group. Students in the digital media intervention demonstrated 89.3% active participation compared to 62.7% in the control group ($p < 0.001$). Sustained attention during instruction was 94.2% in the experimental group versus 71.5% in the control group. Four-week follow-up testing showed superior retention of cognitive understanding in the experimental group. Retention rates for cognitive concepts were 91.2% for the experimental group compared to 73.8% for the control group ($p < 0.001$).

All primary outcome measures demonstrated statistically significant differences with large effect sizes, indicating both statistical significance and practical importance of the intervention. The consistently large effect sizes (Cohen's d > 0.8) across all cognitive domains suggest robust and meaningful improvements in cognitive understanding through interactive digital media intervention.

DISCUSSION

The findings of this study provide compelling evidence for the positive influence of interactive digital media on cognitive understanding in physical education among elementary students. The substantial improvements observed in the experimental group across multiple cognitive domains suggest that digital media technologies offer significant advantages over traditional instructional methods for enhancing cognitive learning in physical education contexts.

The large effect sizes observed (Cohen's d ranging from 3.35 to 4.12) indicate not only statistical significance but also practical importance of the intervention. These results align with previous research demonstrating that interactive learning media can significantly improve learning outcomes and increase students' motivation and engagement.

The mechanism underlying these improvements likely involves multiple cognitive processes. Interactive digital media provides visual representations of complex movement patterns, allowing students to develop clearer mental models of motor skills. The multimedia presentations enable students to process information through multiple sensory channels, enhancing encoding and retention of motor learning concepts.

These findings are consistent with systematic reviews showing positive impacts of digital technology integration on cognitive learning outcomes. The 83% improvement in movement pattern recognition observed in our study supports previous research indicating that video and animation-based approaches are particularly effective for cognitive development.

Our results corroborate findings from Modra et al. (2021) who reported that digital technologies in physical education improve learning effectiveness and motor skills development. Similarly, the high engagement levels observed (89.3% active participation) align with research showing that interactive multimedia increases student motivation and interest in learning activities.

The superior retention rates observed in our experimental group (91.2% versus 73.8%) support research suggesting that interactive digital media creates more durable learning outcomes compared to traditional methods. This finding has important implications for long-term skill development and knowledge transfer in physical education.

The implications of these findings extend beyond immediate learning outcomes. Enhanced cognitive understanding in physical education may contribute to improved motor skill acquisition, better movement quality, and increased physical activity participation throughout life. The development of spatial reasoning skills observed in our study may also transfer to other academic domains and contribute to overall cognitive development.

From a pedagogical perspective, these results suggest that physical education curricula should incorporate interactive digital media to optimize cognitive learning outcomes. Teacher preparation programs must adapt to include digital literacy and technology integration skills specific to physical education contexts.

The high engagement levels observed with digital media intervention have implications for addressing declining physical activity levels among children. By making physical education more engaging and cognitively stimulating, interactive digital media may contribute to developing positive attitudes toward physical activity that persist beyond formal education.

Several limitations should be acknowledged when interpreting these findings. The study was conducted in a specific cultural and educational context (Medan City, North Sumatra, Indonesia), which may limit generalizability to other populations and settings. The relatively small sample size (n=40) and short intervention period (12 weeks) may not capture long-term effects or individual variation in response to digital media intervention.

The quasi-experimental design, while appropriate for educational research, cannot establish definitive causal relationships due to potential confounding variables not controlled in the study. Additionally, the novelty effect of technology introduction may have contributed to improved outcomes, and these effects might diminish over time with repeated exposure.

The study focused specifically on cognitive outcomes and did not examine potential negative effects of technology use, such as reduced physical activity time or over-reliance on digital tools. Furthermore, the cost and accessibility of interactive digital media technologies may present implementation barriers in resource-limited educational settings

CONCLUSION

This study provides robust evidence that interactive digital media significantly enhances cognitive understanding in physical education among elementary school students. The experimental group demonstrated substantial improvements across multiple cognitive domains, including movement principles comprehension, spatial reasoning, and motor learning concepts, with effect sizes indicating both statistical and practical significance.

The research reinforces concepts regarding the potential of educational technology to transform traditional pedagogical approaches in physical education. Interactive digital media offers unique advantages for visualizing complex movement patterns, engaging students in active learning, and providing immediate feedback that enhances cognitive processing of motor skills information.

The importance and potential impact of these findings extend to curriculum development, teacher preparation, and educational policy decisions regarding technology integration in physical education. The evidence supports increased investment in interactive digital media technologies and professional development for physical education teachers to effectively implement these tools.

The correlation between digital media exposure and enhanced cognitive understanding, as demonstrated through improved performance on movement pattern recognition, spatial reasoning, and retention assessments, provides strong evidence for the hypothesis that interactive technologies facilitate more effective cognitive processing in physical education contexts.

Recommendations for Future Research:

Future studies should investigate long-term effects of interactive digital media on cognitive development and motor skill transfer. Research is needed to identify optimal technology integration strategies, examine cost-effectiveness of different digital media approaches, and explore individual differences in response to technology-enhanced instruction. Additionally, studies should investigate the balance between digital and traditional instruction methods to maximize both cognitive and physical learning outcomes in physical education.

Acknowledgments

The authors express gratitude to the elementary schools in Medan City, North Sumatra, Indonesia, for their cooperation in this research. Special thanks to the physical education teachers who facilitated data collection and the students who participated in this study. We acknowledge the support of the local education department and appreciate the technical assistance provided by the educational technology team.

Conflict of Interests

The authors declare no conflicts of interest related to this research. This study was conducted independently without financial support from technology companies or organizations with commercial interests in educational digital media products.

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