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Enhancing Elementary School Students' Cognitive Development through Volleyball Learning Using the Simulation Method on Locomotor, Non-Locomotor, and Manipulative Movements

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Abstract
Physical education in elementary schools plays an important role in developing students' cognitive aspects. Volleyball learning with the simulation method is expected to improve students' cognitive abilities through the development of basic movements. This study aims to determine the effect of volleyball learning with the simulation method on improving the cognitive skills of elementary school students in the aspects of locomotor, non-locomotor, and manipulative movements. The research used an experimental method with a pre-test post-test control group design. The subjects of the study were 32 students (14 boys and 18 girls) from grade 5 of SDN 1 Saban, Gubug District. The instrument used was a validated cognitive test of basic movements. The data were analyzed using paired t-test and independent t-test. The results of the study showed a significant improvement in the cognitive abilities of students in the experimental group, with a significance value of 0.000 < 0.05. The highest improvement occurred in the manipulative movement aspect (32.5%), followed by locomotor movement (28.7%), and non-locomotor movement (25.3%). Volleyball learning using the simulation method is effective in improving the cognitive abilities of elementary school students in all aspects of basic movement studied.

Keywords: cognitive; locomotor movement; manipulative movement; simulation method; volleyball

1. Introduction

Physical education in elementary schools plays a strategic role in developing students' potential holistically, not only in the physical domain but also cognitively, affectively, and psychomotorically. According to Goodway et al. (2012), movement learning in elementary-aged children represents a critical period for fundamental movement skills, which serve as the foundation for developing more complex motor skills. Sports activities are considered a form of effort to enhance the quality of human resources in Indonesia (Asmarani & Setiawan, 2020). According to Bangun (2012), the purpose of physical education is to provide children with opportunities to learn various activities that nurture and develop their potential, covering physical, mental, social, emotional, and moral aspects. Physical education is a process conducted through physical activities, games, or sports selected specifically to achieve educational objectives (Bekham et al., 2023).

One of the goals of Physical Education, Sports, and Health (PES) subjects, according to Ningsih et al. (2020), is to improve students' basic motor skills. Motor development is crucial for physical education because movement is essential for the growth and development of young children, who experience rapid development during this stage (Humaira et al., 2024). Concentration is a key

element in maintaining focus and motor skills, which are necessary in fast-paced game situations (Arwandi & Firdaus, 2021; Marwanto Saputra et al., 2023; Nurhidayat et al., 2019).

Volleyball, as a ball game, has unique characteristics in developing students' cognitive abilities. Volleyball is an example of a movement activity that engages the whole body (Pamungkas et al., 2024). Teaching volleyball in elementary schools aims to introduce basic volleyball movements early to children aged 9–13 years (Triatmojo et al., 2025). Within schools, volleyball is a popular sport often developed through extracurricular activities (Raharja & Abdulaziz, 2025). Volleyball involves various fundamental movement skills, including locomotor (running, jumping), non-locomotor (twisting, bending), and manipulative movements (hitting, catching, throwing), which require coordination and tactical understanding. Tomporowski (2003) found that structured physical activity can enhance children's cognitive functions, including memory, attention, and problem-solving abilities. However, the appropriate learning method is key to achieving these goals.

The simulation method in physical education allows students to experience learning situations that resemble real game conditions in a controlled environment. Joyce et al. (2015) stated that simulation methods can improve conceptual understanding and learning transfer in students.

Based on initial observations at SDN 1 Saban, students' cognitive abilities in understanding basic movement concepts were still low, as evidenced by their limited ability to analyze and evaluate basic volleyball techniques. Therefore, innovative learning strategies are needed to enhance students' cognitive abilities through volleyball learning. The research problem is formulated as follows: can volleyball learning using the simulation method improve elementary students' cognitive abilities in locomotor, non-locomotor, and manipulative movements?

Cognitive ability is a mental process involving knowledge, comprehension, application, analysis, synthesis, and evaluation (Marta et al., 2024). In movement learning, cognitive skills play a crucial role in understanding techniques, tactics, and game strategies. Schmidt and Wrisberg (2008) describe three stages in movement learning: (1) the cognitive stage, where students try to understand movement concepts; (2) the associative stage, where students begin to automate movements; and (3) the autonomous stage, where movements become automatic.

Goodway et al. (2012) classify fundamental movements into three categories:

1. Locomotor movements, movements that transport the body from one place to another. In volleyball, locomotor movements include running to chase the ball, jumping for spikes or blocks, and moving to take position.
2. Non-locomotor movements, movements performed in place without changing location. In volleyball, this includes twisting to face the ball, bending to receive a low ball, and stretching to reach a high ball.
3. Manipulative movements, controlling objects using hands or feet. In volleyball, manipulative movements include passing, setting, spiking, serving, and blocking.

The simulation method provides learning experiences through simulated situations to achieve learning objectives (Joyce et al., 2015). In physical education, simulation can involve game situations, movement techniques, strategies, and tactics. According to Sudjana (2005), the

advantages of the simulation method include increasing students' learning motivation, providing meaningful learning experiences, developing critical thinking, and enhancing learning transfer.

Volleyball learning for elementary students must align with children's developmental characteristics. According to the FIVB, modified volleyball for children includes a smaller court size, adjusted net height, a lighter and softer ball, and simplified rules.

2. Method

This study employed an experimental method with a pre-test post-test control group design. The research design can be illustrated as follows:

Group	Procedure
Experimental Group	$O_1 \rightarrow X \rightarrow O_2$
Control Group	$O_3 \rightarrow C \rightarrow O_4$

Notes:
O_1, O_3 = Pre-test
O_2, O_4 = Post-test
X = Treatment using the simulation method
C = Conventional learning

Sampling Technique

The sample was taken from the population being studied (Tanzeh & Arikunto, 2014). The population consisted of all fifth-grade students of SDN 1 Saban, Gubug Subdistrict, Grobogan Regency, in the 2024/2025 academic year, totaling 64 students. A sample of 32 students was selected using random sampling, consisting of 14 boys and 18 girls. The sample was divided into two groups:

Experimental Group: 16 students (7 boys, 9 girls)
Control Group: 16 students (7 boys, 9 girls)

Variables

Independent Variable: Volleyball learning using the simulation method
Dependent Variable: Students' cognitive abilities in locomotor, non-locomotor, and manipulative aspects

Instruments

The instrument used was the Volleyball Basic Movement Cognitive Test (TKGDBV), validated with a construct validity of 0.87 and reliability of 0.92. The test components included:

1. Locomotor Cognitive Test (15 items): Knowledge of movement patterns in volleyball, understanding of timing and positioning, analysis of running and jumping techniques.
2. Non-Locomotor Cognitive Test (15 items): Knowledge of correct body posture, understanding of balance and stability, analysis of rotation and flexion movements.

3. Manipulative Cognitive Test (20 items): Knowledge of basic volleyball techniques, understanding of eye-hand coordination, analysis of timing and movement accuracy.

Scoring: Each correct answer was scored 1, and incorrect answers were scored 0.

Research Procedures

Preparation Phase:

1. Preparation and validation of instruments
2. Determination of the sample and group allocation
3. Pre-test for both groups

Implementation Phase:

1. Experimental Group: Volleyball learning using the simulation method for 8 sessions (2x per week, 2 × 35 minutes per session). Simulation-based learning structure:
   Simulation of game situations (15 minutes)
   Analysis and discussion (10 minutes)
   Basic movement practice (35 minutes)
   Evaluation and reflection (10 minutes)
2. Control Group: Conventional volleyball learning with the same structure but without the simulation component

Management Aspects:

Planning, organizing, staffing, motivating, and controlling were applied to ensure the implementation ran effectively.

3. Result and Discussion

Product Description

Table 1. Description of pre-test and post-test data

Movement Aspect	Group	Pre-test Mean ± SD	Post-test Mean ± SD	Improvement (%)
Locomotor	Experimental	8.2 ± 1.4	10.6 ± 1.2	28.7%
	Control	8.1 ± 1.3	8.9 ± 1.4	9.2%
Non-Locomotor	Experimental	7.9 ± 1.5	9.9 ± 1.3	25.3%
	Control	8.0 ± 1.4	8.6 ± 1.5	7.5%
Manipulative	Experimental	11.2 ± 2.1	14.8 ± 1.8	32.5%
	Control	11.0 ± 2.0	12.1 ± 2.2	10.0%

Table 2. Independent t-test results (experimental vs control group)

Movement Aspect	t-value	df	Sig. (2-tailed)	Mean Difference	Note
Locomotor	4.256	30	0.000	1.7	Significant
Non-Locomotor	3.187	30	0.003	1.3	Significant
Manipulative	4.892	30	0.000	2.7	Significant

Cognitive Improvement in Locomotor Movements

The results indicate that volleyball learning using the simulation method significantly improved students' cognitive abilities in locomotor movements ($p = 0.000 < 0.05$). The experimental group showed an improvement of 28.7%, which is considerably higher than the control group's 9.2%.

This aligns with research suggesting that simulation-based learning enhances students' understanding of movement concepts by providing meaningful, concrete experiences (Nurhayati et al., 2025). In locomotor movements, students better understand timing, positioning, and movement coordination through varied simulated game situations. Simulation allows students to analyze different locomotor situations in volleyball, such as: analyzing running patterns to take receiving positions, understanding jump timing for spikes and blocks, coordinating foot movements during service.

Cognitive Improvement in Non-Locomotor Movements

The cognitive ability for non-locomotor movements in the experimental group increased significantly by 25.3% ($p = 0.000 < 0.05$), while the control group showed no significant improvement ($p = 0.084 > 0.05$). This improvement can be explained through Vygotsky's constructivist learning theory, where students build knowledge through social interaction and direct experience (Tamrin et al., 2011). Through simulation, students can: understand the importance of correct body posture in various situations, analyze body balance when receiving balls from different directions, evaluate the effectiveness of rotational and flexion movements in gameplay.

Cognitive Improvement in Manipulative Movements

Manipulative movements showed the highest improvement in the experimental group (32.5%) with significance $p = 0.000 < 0.05$, indicating that the simulation method is highly effective in enhancing students' understanding of manipulative volleyball techniques. According to Schmidt & Lee (2011), manipulative skills require complex coordination between visual perception, cognitive processing, and motor execution. The simulation method facilitates this process by: providing varied gameplay scenarios, allowing students to analyze the correct techniques for each situation, developing prediction and anticipation abilities.

Effectiveness of the simulation method

The advantages of the simulation method in this study can be summarized as:

1. Meaningful Learning: Provides real and meaningful contexts, increasing motivation and engagement
2. Active Learning: Students actively participate, analyzing, evaluating, and synthesizing knowledge
3. Learning Transfer: Experiences in simulations can be applied to real game situations, improving adaptability
4. Metacognitive Development: Encourages students to reflect on their own thinking processes

Practical implications

The study has practical implications for elementary physical education:

1. Curriculum Development: Simulation methods can be integrated to enhance students' cognitive aspects
2. Teacher Training: PE teachers should be trained to implement simulation-based learning
3. Provision of Facilities: Schools need to provide appropriate infrastructure to support simulation-based learning

Research limitations

1. The sample was limited to one school

2. The study duration was relatively short (8 sessions)
3. Factors such as student motivation and interest were not controlled
4. The test instrument measured only cognitive aspects, not psychomotor skills

4. Conclusion and Recommendation

Based on the research results and discussion, it can be concluded that: (1) Volleyball learning using the simulation method significantly improves elementary students' cognitive abilities in locomotor movements, with an improvement of 28.7% ($p = 0.000 < 0.05$); (2) Volleyball learning using the simulation method significantly improves elementary students' cognitive abilities in non-locomotor movements, with an improvement of 25.3% ($p = 0.000 < 0.05$); (3) Volleyball learning using the simulation method significantly improves elementary students' cognitive abilities in manipulative movements, showing the highest improvement of 32.5% ($p = 0.000 < 0.05$).

Based on the research findings, the following recommendations are suggested for teachers implement the simulation method in volleyball learning to enhance students' cognitive abilities. For Schools provide facilities and support for the development of simulation-based learning.

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