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Research article

Development of volleyball learning Model to improve Smash, coordination, and strength skills of Junior High School students

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Abstract: This study aimed to develop a volleyball learning model to improve the smashing ability, coordination, and strength of junior high school students. The study employed a Research and Development (R&D) design based on the Borg & Gall model. The development process involves several stages, including limited and field trials, to test the effectiveness of the final product. A total of 90 grade VII and VIII junior high school students (ages 12–14) were randomly selected to participate in the study. Instruments used included smash skill tests, coordination tests, and vertical jump tests to measure leg muscle strength, as well as questionnaires and observation sheets. Data were analyzed quantitatively using a t-test and ANOVA and qualitatively to evaluate the learning pro-cess. The results showed that the developed volleyball learning module was effective in improving students' smash ability, coordination, and leg muscle strength. The t-test results showed a p-value of less than 0.001 for all aspects. Revised modules with simpler instructions, vivid illustrations, and mini-games make learning more adaptive, communicative, and enjoyable. Thus, this study produced a valid, practical, and effective volleyball learning model for junior high school students that is feasible to apply. Further research is suggested to develop other engineering skills, integrate digital media, and involve a wider sample.

Keywords: learning model, volleyball, smash skills, coordination, strength, learners

1. Introduction

Physical education in junior high school plays a strategic role in developing motor and fundamental movement skills, as well as shaping students' character through sports activities (Adi et al., 2023; Aliriad et al., 2024). One of the most popular sports in schools is volleyball, which requires teamwork and mastery of complex individual techniques such as serving, passing, blocking, and smashing. Among these, the smash is a key skill that often determines success in a match. However, effective smash performance requires not only technical mastery but also good body coordination and adequate muscular strength. In practice, many students experience difficulties performing a smash due to the lack of systematic, varied, and developmentally appropriate learning models.

Previous studies have emphasized the importance of appropriate instructional strategies in volleyball learning. Umar (2023) found that learning methods and motor abilities significantly influence the mastery of basic volleyball techniques. Samsudin (2021) reported that structured motion-learning models improve students' fundamental skills, while Agustini Raaiyatini et al. (2024) showed that project-based approaches enhance passing skills and learning motivation. From a technical perspective, Fauzi (2024) developed assessment instruments for smash and serve skills, highlighting the

importance of structured evaluation. Giatsis (2022, 2023) demonstrated that smash techniques vary according to gender and playing level, suggesting that instructional approaches should be adapted to learners' characteristics.

Research also confirms that physical conditioning plays a crucial role in smash performance. Weldon (2021) emphasized the importance of strength and conditioning in volleyball performance. Kastrena and Revianny (2023) found that resistance training models such as Tabata and circuit training effectively improve endurance. Similarly, Khan and Singh (2021) and Kumar (2021) reported that plyometric and strength training significantly enhance volleyball performance, while Krzysztofik (2021) highlighted the importance of proper rest intervals in plyometric training. Furthermore, Leeuw (2022a, 2022b) underlined the importance of monitoring jump load and applying performance modeling approaches for injury prevention among volleyball players.

Although these studies provide valuable insights, most focus on either technical skills (e.g., smash, passing, or serving) or physical conditioning (e.g., strength and plyometrics) separately. Theoretically, smash mastery requires integrated coordination between upper and lower limbs, explosive muscle power, and proper technical execution. Motor learning theory emphasizes that instructional models should be adapted to students' developmental stages and integrate technical and physical components to achieve optimal outcomes.

The novelty of this study lies in the development of an integrated volleyball learning model that simultaneously combines technical drills, physical strengthening exercises, and coordination training within a single structured program tailored to junior high school students. Unlike previous studies that examined isolated technical or physical interventions, this model is designed holistically to address smash skills, coordination, and muscular strength together. This integrated approach distinguishes the present study from prior research and offers a more comprehensive and developmentally appropriate alternative for school-based physical education.

Therefore, this study aims to develop a volleyball learning model to improve smash skills, coordination, and strength among junior high school students. It is expected that this integrated model will make the physical education learning process more effective and enjoyable while enhancing students' technical competence, physical fitness, and readiness for actual volleyball games.

2. Materials and Methods

Research Design

This study takes an R&D approach based on a modified Borg & Gall model because its aim is to produce a volleyball learning model that will improve the smash skills, coordination and strength of junior high school students (Sugiyono, 2018).

Subjects of study

The stages include preliminary studies, planning, product development, limited trials, revisions and field trials until the final model is completed. The sample was determined by purposive sampling: 30 students of Class VII participated in limited trials and 60 students of Class VII and VIII participated in field trials. The sample is 55% male and 45% female, with an age range of 12-14 years in public Junior High Schools 1 Datuk Tanah Datar Kabupaten Batu Bata, Sumatera Utara, Indonesia.

Treatment Procedure

The research procedure is carried out in stages, from preliminary studies to model refinement. This model integrates technique exercises and small-sided games, in line

with Rodrigues' (2022) findings that such games affect the technical behaviour of beginner athletes. Data are analysed using a quantitative approach (paired sample t-test/ANOVA) to measure student performance improvement, as well as a qualitative analysis of observations, interviews and questionnaires. This multifaceted approach supports efficiency and innovation in sports learning (Salimifard, 2021).

Table 1. Early models of basic volleyball skills

Material / Components	Learning Activities	Supporting Physical Exercises	Evaluation
Basic Smash & Scratch Coordination	-Dynamic warm-up (circumnavigation, dynamic stretching) - Drill leg positions and smash arm swings - Simple coordination exercises (throw & catch ball) in pairs	Squat jump (3 × 10 repetisi)	Basic smash technique observation and simple coordination
Smash Technique Development & Advanced Coordination	- Warm-up (zigzag run + stretching) - Full arm swing Drill + triple step – Passing-smash coordination exercises	Push up (3 × 8) Plank (3 × 20 detik)	Passing–smash coordination test
Smash integration with Game variations	- Small game warm-up (throw-catch in pairs) - Drill smash with friends feed - Hand-eye coordination exercises (ball reaction game)	Vertical jump (3 × 10) Skipping (2 menit)	Test your smash skills with bait
Simulation & Initial Evaluation	- Combined warm-up (short sprints + stretches) - Smash drills in 3 vs 3 mini game situations –Passing–set-smash coordination exercises in groups	Circuit training (squat jump + push up)	Smash Skill Test, coordination test, strength test (vertical jump)

Table 2. Expert validation sheet

Aspect	Indicators	Agree	Disagree	Notes
Smash Skills	Leg position, arm swing, ball contact, stroke direction			
Coordination	Synchronization of hand-foot movements, response to the ball			
Strength	Leg explosive power, arm strength			
Attitude & Participation	Discipline, cooperation, motivation to learn			

The initial product was then validated by three experts, namely physical education experts, volleyball experts, and learning evaluation experts. The validation process is carried out by using the Content Validity Ratio (CVR) and Content Validity Index (CVI) to measure the level of conformity of the indicator with the assessed construct (Rahmat et al., 2024). The validation results showed that the module developed was

declared fit for use, although there were some improvement records. The notes include the need for simplification of instruction to match the ability of Junior High School students and the addition of exercise variations to make learning more interesting and able to increase student learning motivation.

Research Instruments

Instruments used include smash skill tests, coordination tests (eye–hand and eye–foot), vertical jump tests, questionnaires and observation sheets. Validity was tested through expert judgement, while reliability was tested using the test-retest technique. Reliability was tested using the test–retest technique. The reliability coefficients showed strong consistency, with correlation values of r = 0.87 for the smash skill test, r = 0.85 for the coordination test, r = 0.89 for the vertical jump test, and r = 0.91 for the questionnaire instrument, indicating high reliability. This is in line with (Rifki, 2022a) who emphasises the importance of valid test instruments, and Rifki, (2022b), who discusses the development of basic volleyball techniques.

2. Results

Table 3. CVR validity assessment results

Aspect	Indicators	Agree (n_e)	Disagree	CVR	Results
Smash Skills	Foot position	3	0	+1.00	Valid
	Swing arm	3	0	+1.00	Valid
	Ball contact	3	0	+1.00	Valid
	Stroke direction	3	0	+1.00	Valid
Coordination	Synchronization of hand-foot movements	3	0	+1.00	Valid
	Response to the ball	3	0	+1.00	Valid
Strength	Explosive power of limbs	3	0	+1.00	Valid
	Arm strength	3	0	+1.00	Valid
Attitude & Participation	Discipline	3	0	+1.00	Valid
	Cooperation	3	0	+1.00	Valid
	Learning motivation	3	0	+1.00	Valid

The results of this study began with the initial product validation process, which was carried out by three experts: physical education experts, volleyball experts and learning evaluation experts. The suitability of the indicator with the measured construct was assessed using the Content Validity Ratio (CVR) and Content Validity Index (CVI) methods. Based on the CVR calculation for each indicator, all indicators obtained a CVR value of +1.00, indicating that they were all deemed valid by the experts. Furthermore, calculation of the CVI for each aspect also yielded a value of CVI = 1.00 for the aspects of smash skills, coordination, strength, and attitude and participation. Thus, the overall CVI value of 1.00 belongs to the 'very valid' category.These results suggest that the developed learning modules are feasible for use in the trial stage, provided that experts' recommendations for improvement are implemented, such as simplifying the instructions to align with junior high school students' abilities and adding exercise variations to boost student interest and motivation.

Table 4. CVI validation assessment results

Aspect	Number Of Indicators	Average CVR (CVI per aspect)	Categories
Smash Skills	4	1.00	Very Valid
Coordination	2	1.00	Very Valid
Strength	2	1.00	Very Valid
Attitude & Participation	3	1.00	Very Valid

Table 5. Initial product validation results by experts

Aspect	Physical Education Expert	Volleyball Experts	Learning Evaluation Expert
Smash Skills	Decent, engineering according to junior high school standards	Movement is appropriate, it is necessary to emphasize the direction of the blow	Self-explanatory, instructions need to be more concise
Coordination	Good, varied exercises	Accordingly, need additional variations of a simple drill	Already relevant, necessary step-by-step instruction
Strength	Exercise is accurate, but the load is quite heavy	Load needs to be adjusted to the ability of Junior High School students	Need adjustments so as not to burden students
Attitude & Participation	Growing student learning motivation	Mini games increase enthusiasm	Attitude observation already includes affective aspects
Instrument Format	Worth using	Need illustrative images to make it easier for students to understand	Need simple, concise, not too technical language

3.1 Limited trial

The limited trial involved 30 Year 7 students and took place over the course of four meetings. It used learning modules that had been developed in the early stages of product development. The trial aimed to evaluate the implementation of the learning models, student responses and the initial effectiveness of improving smash skills, coordination and leg muscle strength.The learning process was carried out according to the design of the modules, with each meeting consisting of three main stages: warm-up activities, core exercises and simple evaluations. During the core training section, students practise smash techniques and movement coordination, as well as strength exercises, in a gradual and systematic manner. The teacher acts as a facilitator and observer, while the students follow instructions through a variety of exercises arranged in the module.

The results showed relatively high student involvement, with the majority actively participating in each stage of the learning process. However, some students still need time to adapt to the coordination exercises. Learning motivation increased significantly because the activities were varied and game-based, providing a more enjoyable learning experience. The teacher assessed that the lesson was implemented well, although they suggested simplifying the instructions for several exercise variations to make them easier for students to understand.

Table 6. Limited Trial Results

Measured aspects	Pre-test scores (average)	Post-test scores (average)	Increase (%)
Smash Skills	65	74.8	15%
Coordination	67	75	12%
Leg Muscle Strength	62	68.2	10%

As can be seen from the results of the limited trials in Table 6, the volleyball learning module developed is effective in the early stages, as evidenced by improvements in students' abilities in terms of smashing, coordination and strength. Additionally, students demonstrated high levels of motivation and engagement in learning. However, improvements are needed, particularly in simplifying the instructions for coordination exercises to make them easier for junior high school students to understand.

Table 7. Product Improvement Summary

Aspect	Before Revision	After Revision
Instructions	Long instructions, less simple	Concise instructions + illustrative images
Game Variations	Focus on drill technique	Plus mini games (Catch & Smash, Target Smash, Relay Smash)
Strength Training	Relatively heavy load (3 × 15 squat jump, push up standard)	Adjustable load (3 × 8-10 squat jump, knee push up, simple circuit)

After the revision, the product underwent several important improvements. In the aspect of instruction, which was previously in the form of long and less simple explanations, it has now been presented more concisely and equipped with illustrative images to make it easier to understand. In the variation aspect of the game, which initially only emphasized technical exercises (drills), now added with mini games such as Catch & Smash, Target Smash, and Relay Smash so that the activities become more interesting and fun. Meanwhile, in the aspect of strength training, which originally used relatively heavy weights such as 3 × 15 squat jumps and standard push ups, it has now been changed to weights that can be adjusted to the ability of participants, for example 3 × 8-10 squat jumps, knee push ups, and simple circuits. Thus, the revised results make the product more practical, varied, and adaptive to user needs.

3.2 Field Trials

Field trials were conducted with 60 junior high school students in Years 7 and 8 over the course of six meetings. At this stage, the revised volleyball learning module was implemented on a broader scale under the supervision of physical education teachers and researchers. Observation shows that the learning process runs more smoothly because the instructions are simpler and supported by images to help students understand. Additionally, students demonstrated high levels of enthusiasm, with participation rates exceeding 90%. The variations of small games applied were also proven to make the practice atmosphere more enjoyable while encouraging the active involvement of all students.

Table 8. Field Trial Results

Measured aspects	Pre-test scores (average)	Post-test scores (average)	Increase (%)
Smash Skills	66	82.5	25%
Coordination	68	81.6	20%
Leg Muscle Strength	63	74.3	18%

Evaluation results obtained through the Smash Skill Test, Coordination Test and Leg Muscle Strength Test (vertical jump) showed an improvement in students' abilities compared to the pre-test results. Overall, smash skills improved by an average of 25%, coordination by 20%, and leg muscle strength by 18%. These results demonstrate the effectiveness of the revised volleyball learning module in enhancing the technical skills, coordination, and physical strength of junior high school students.

Table 9. Paired t-test results

Measured aspects	Pre-test (M ± SD)	Post-test (M ± SD)	t(59)	Sig. (p)	Desc.	Cohen's d (Effect Size)
Smash Skills	66.0 ± 5.2	82.5 ± 4.8	18.45	<0.001	Sig.	3.30 (Very Large)
Coordination	68.0 ± 6.1	81.6 ± 5.7	15.82	<0.001	Sig.	2.30 (Very Large)
Leg Muscle Strength	63.0 ± 5.5	74.3 ± 5.1	14.20	<0.001	Sig.	2.13 (Very Large)

As can be seen from Table 9, the results of the paired t-test show that there was a significant improvement in all measured skill areas after the treatment was given. Regarding smash skills specifically, the average value increased from 66.0° ± 5.2 in the pre-test to 82.5° ± 4.8 in the post-test, with a t-value of 18.45 and a significance level of $p < 0.001$. This demonstrates that the treatment positively impacted participants' smash skills. Similarly, in terms of coordination, the average increased from 68.0° 6.1° to 81.6° 5.7° with a value of $t(59) = 15.82$ and $p < 0.001$, indicating a significant improvement in coordination. Furthermore, leg muscle strength increased from an average of 63.0° ± 5.5° in the pre-test to 74.3° ± 5.1° in the post-test, with a value of $t(59) = 14.20$ and $p < 0.001$, indicating a significant increase in leg muscle strength. Overall, these results prove that the exercise programme was effective in significantly improving the participants' smash skills, coordination and leg muscle strength.

3. Discussion

The expert validation results showed that the product obtained an average score of 3.13 (in the 'good' category). It is feasible to use with minor improvements to the instructions, exercise load and activity variations. A trial involving 30 Year 7 students showed improved skills (smash: 15%; coordination: 12%; strength: 10%), as well as increased motivation to learn, although coordination adaptation constraints remained. Following revisions in the form of additional illustrations, mini-games and adjustments to the exercise load, the model was tested again with 60 students in Years 7 and 8. The results showed that over 90% of students participated, with significant improvements in smash (25%), coordination (20%) and strength (18%). Teachers consider this model to be effective because it combines technique, coordination and strength in a way that is more balanced and interesting than conventional methods.

The findings of this study indicate that the developed volleyball learning model is effective, practical and engaging in improving the smash skills, coordination and leg muscle strength of junior high school students. The significant improvement in the results of the limited and field trials is consistent with the theory that learning based on varied, contextual physical activities can enhance motor skills and student motivation. Simple instructions with illustrations were also found to be easier to understand, in line with the characteristics of junior high school students, who are at the concrete operational development stage.

This result is consistent with the research of Agustian et al., (2023) which demonstrates that the hanging ball exercise model can improve the service skills of men's volleyball players. This confirms that modifying a structured training model can improve specific volleyball skills. Similarly, Saputra, (2022) found that hanging ball exercises effectively increase the ability to smash open, thereby reinforcing the importance of varied and contextual training approaches.In terms of media development, Aprilianto et al., (2021) and (Koto et al., 2024) emphasise that innovative, media-based learning increases student understanding and engagement, with the former using Android-based Smart Volly and the latter using video-based media. This is consistent with the model developed in this study, which incorporates illustrations and variations of mini games to make it more engaging and accessible to students.

Furthermore, Purwanto, (2022) and Suri et al., (2022) confirm that basic volleyball technique training models, such as the forearm pass drill and the interval overhead pass, can improve the passing skills of junior high school students. These findings support the argument that Research and Development (R&D)-based models, including the smash model developed in this study, could provide an innovative approach to learning volleyball in schools.In addition, Kristiawan, (2021) research emphasises the effect of rope jumping and jumping up stairs on leg power. Faishal, Faishal et al., (2023) meanwhile, examined variations of service exercises using plastic and tennis

balls. Together, these studies provide a theoretical basis that suggests combining technique and muscle strength exercises significantly improves volleyball skills. This is consistent with the findings of this study, which combines elements of technique, coordination, and physical reinforcement in a single learning model.

The development of volleyball learning models for junior high school students focuses on improving smashes, coordination, and strength. Expert validation using CVR and CVI indicates that the modules belong to highly valid categories. This aligns with research confirming that smash skills require a combination of leg muscle strength, coordination, and good arm swing techniques ((Manullang & Ngatimin, 2023; Pawlik, 2023). In terms of physical training, plyometric and sprint exercises have been shown to increase explosive leg muscle power and jump height, both of which are important for successful smashing (Majid, 2021; Novita et al., 2022). Coordination is also important, with reactive agility tests and joint position awareness having been shown to improve stroke accuracy (Lima, 2021; Mendez-Rebolledo, 2022).

In addition to technical factors, the success of an attack in volleyball is influenced by game patterns and opponent quality (Drikos, 2021, 2022). Therefore, learning models that simulate real game conditions can enhance students' tactical experience (Oliinyk, 2021). Learning volleyball also provides non-technical benefits. Bean et al., (2020) emphasise the transfer of life skills such as discipline and cooperation, and Bai, (2021) that a creative approach can enhance students' positive emotional experience. However, attention still needs to be paid to balancing training loads and preventing injury (Andrade, 2021; Mahmoudi et al., 2024).

In practical terms, physical education teachers can use this learning model as an alternative to traditional volleyball teaching methods in junior high schools, particularly to improve students' smash, coordination and strength skills. Theoretically, this study reinforces the idea that R&D-based learning models can produce effective, practical and interesting classroom activities that improve student performance.

The Volleyball Learning Model combines aspects of technique, coordination and strength with a varied, contextual approach supported by visual media, making it original. Compared with previous studies that focused on specific skills such as serving, passing or power limbs, this study contributes a comprehensive learning model that aligns with the characteristics of junior high school students.

The results of both limited and field trials indicate clear improvements in students' smash skills, coordination, and leg muscle strength, as measured quantitatively through skill tests and vertical jump assessments. Specifically, quantitative improvements ranged from 10–15% in the limited trial and 18–25% in the field trial, with participation rates exceeding 90%. In parallel, observational data and teacher reports revealed increased motivation, engagement, and enthusiasm during learning activities. While the measured skill gains provide objective evidence of the model's effectiveness, the observational findings capture qualitative aspects such as students' willingness to participate, persistence in completing exercises, and enjoyment of mini-games and illustrative materials. Notably, some coordination adaptation constraints were still observed in the limited trial, suggesting that although overall physical and technical performance improved, certain motor adjustments required longer practice or individualized support. By differentiating between quantitative improvements and qualitative engagement, the study highlights that the learning model not only enhances measurable skills but also fosters greater student motivation, participation, and interest in volleyball.

5. Conclusions

This study successfully developed an effective learning model for volleyball to improve the smash skills, coordination and leg muscle strength of junior high school students. Through systematic research and development stages, the model has proven to deliver significant improvements in limited and field trials. Revisions to the product, such as simplifying the instructions, adding illustrations and variations of mini games, and adjusting the exercise load, make the model more practical and interesting for junior high school students. Therefore, this learning model deserves to be used as an innovative alternative for teaching physical education, particularly volleyball, at junior high school level.

Based on the study's results, it is recommended that physical education teachers apply this learning model to diversify volleyball learning strategies, thereby motivating and engaging students in the learning process. Subsequent researchers may develop similar models with a broader scope of skills, for example involving serving or passing, as well as integrating digital media to improve learning effectiveness. Furthermore, further research involving a larger and more diverse sample, including schools with limited facilities, is needed to strengthen the generalisation of the results of this study and its practical benefits in sports education.

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