

Development of an Undehand Serve Learning Model in Sepak Takraw for 2023 Cohort PJKR Students

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ABSTRACT

This comprehensive study aimed to design, develop, and evaluate a valid, practical, and highly effective adaptive table tennis learning model specifically tailored for students with mild intellectual disabilities (tunagrahita) to enhance their basic motor skills, hand-eye coordination, and overall learning engagement. The research employed the Research and Development (R&D) method based on the Borg and Gall model, systematically covering needs analysis, product design, expert validation, product revision, small-group trials, and large-group trials. The subjects of this study were students with mild intellectual disabilities at SLB Bhakti Putra Palu. The core of the developed learning model integrated critical pedagogical and ergonomic modifications: lighter paddles (70-100 grams to prevent muscle fatigue), colorful and sound-producing balls (to provide continuous auditory and visual tracking stimuli), adjusted table dimensions, and simplified playing rules (e.g., allowing the ball to bounce twice to increase reaction time). Data were comprehensively collected through structured observations, expert validation questionnaires, and performance documentation, subsequently analyzed using descriptive percentages. The findings indicated that the adaptive model received high validation scores of 75.00% from pedagogical experts and 83.33% from table tennis experts, categorizing it as "Feasible to Use." The subsequent field trials demonstrated substantial and progressive effectiveness, with a small-group trial score of 89.28% and a large-group trial score of 94.40%. The strategic inclusion of preliminary cognitive-motor stimuli, specifically shadow strokes, significantly aided muscle memory formation before actual ball contact. It can be firmly concluded that this adaptive table tennis learning model is highly feasible, practical, and effective in facilitating basic table tennis techniques, significantly improving motor coordination, and fostering self-confidence among students with intellectual disabilities.

Keywords: *Adaptive Learning, Table Tennis, Intellectual Disability, Motor Skills, Research and Development, Special Education.*

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INTRODUCTION

Physical education occupies an essential position within the national education constellation, aiming to develop the physical, motor, emotional, and social aspects of students holistically. Not exclusively for regular students in public schools, physical education is also a highly vital component in the education system for children with

special needs, including those with intellectual disabilities (tunagrahita). Properly designed, systematic, and individualized adaptive physical education can serve as a primary medium to foster self-confidence, cooperation, and basic motor skills that often lag due to their inherent impairments (Mustafa, 2020).

In clinical and psychological terminology, children with intellectual disabilities are individuals who experience significant intellectual impairments, generally characterized by an Intelligence Quotient (IQ) score below average (less than 70), which directly impacts their cognitive limitations, social functioning, and adaptive behaviors emerging before the age of 18 (Hallahan & Kauffman, 2020). Based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V), intellectual disabilities are classified into mild, moderate, severe, and profound categories. These intellectual limitations comprehensively cause them to often experience difficulties in understanding abstract concepts, solving problems, remembering multi-step instructions, and coordinating basic motor movements. In the motor domain, many children with intellectual disabilities have low fitness levels, slow movement coordination, poor balance, and weaknesses in both fine and gross motor skills. Therefore, the physical education approach for children with intellectual disabilities absolutely cannot be equated with that for regular students. A specific, directed, highly concrete, repetitive, and modified learning model is required so that the teaching and learning process remains effective, safe, and enjoyable (Sari et al., 2024).

Physical activities and sports implemented with adaptive methods have been empirically proven to be highly effective in stimulating neuromuscular skills, increasing concentration, and training the social abilities of children with intellectual disabilities. One highly potential and flexible sport to be used as an adaptive learning medium is table tennis. The characteristics of table tennis, which are relatively light, have rules that can be simplified, and do not require excessively large mobility areas (running areas), make it highly ideal for stimulating motor responses and eye-hand coordination (Siedentop, 2021). Precise ball-striking movements in table tennis involve quick responses to the object's direction and speed, which directly train proprioception and reflexes. Additionally, this sport is psychologically beneficial as it can foster self-confidence through the achievement of small targets (small wins), reduce stress levels, and function as a form of occupational therapy for children with intellectual impairments.

Despite having various positive potentials and extraordinary therapeutic benefits, facts on the ground show a different reality. Based on preliminary studies and in-depth observations conducted at the Special School (SLB) Bhakti Putra Palu, the table tennis learning model still uses a general (orthodox) approach that has not been systematically modified. Students with intellectual disabilities, especially in the mild and moderate categories, still struggle significantly to follow the learning dynamics due to the use of international standard facilities and equipment. The use of conventional paddles that are too heavy (with a mass ranging from 150-200 grams) makes it difficult for children to swing and causes rapid arm muscle fatigue. Standard table sizes (274 cm x 152 cm x 76 cm) are deemed disproportionate to the children's reach and height. Moreover, the movement of standard ping-pong balls, which is too fast without any additional sound stimuli, and the single-bounce rule that demands split-second reaction times, heavily burden their cognitive and physical processing capacities. The lack of specific guidelines adapted to the characteristics of children with intellectual disabilities cumulatively results in low student engagement, decreased intrinsic motivation, frustration, and slow motor coordination development.

Responding to the significant research gap between the special needs of students with intellectual disabilities and the availability of adaptive learning models, this study focuses on innovation and intervention through the development of a comprehensively modified table tennis learning model. The modifications developed and offered in this study cover two fundamental aspects: (1) Equipment aspects, which include adjusting the paddle weight to be much lighter (70-100 grams) with safe materials, using a table whose size is reduced to resemble a study desk, and using larger, colorful balls equipped with sound-producing elements (bells) to stimulate visual and auditory attention simultaneously; (2) Regulatory and pedagogical aspects, which include adapting game rules allowing the ball to bounce up to twice on the table to provide an extension of reaction time for the children, as well as integrating highly visual, repetitive, and participatory learning stages, supported by visual aids such as illustrated guidebooks and the shadow stroke method.

Relevant previous research was conducted by Purwanto (2017) regarding the development of a basic table tennis technique learning model. However, that study focused solely on regular elementary school students and did not reach or conduct trials in the special education domain (SLB). Similarly, research by Sukriadi & Arif (2021), which designed an adaptive physical education learning model for intellectual disabilities, was still limited to general games and did not delve deeply into a specific sport like table tennis. Therefore, this study aims to design, develop, validate, and test the feasibility and effectiveness of a systematically designed adaptive table tennis learning model specifically for children with intellectual disabilities. It is hoped that the results of this development will not only contribute to special education literature but also serve as a valid, practical, and reliable pedagogical solution for physical education teachers in inclusively facilitating the motor development, balance, and social interactions of children with special needs

METHODS

This study utilized a Research and Development (R&D) design approach. The R&D method is defined as a research method systematically used to produce certain products, and subsequently test the effectiveness, feasibility, and practicality of these products in the real world (Sugiyono, 2019; Waruwu, 2024). The development design in this study specifically adapted the classic development model of Borg and Gall (1983). This model was selected for its logical, comprehensive, and highly structured stages to produce an educational product that is valid, applicable, and empirically tested for effectiveness in the field.

To align with the research context, time allocation, and field urgency, the research process of the original 10-step Borg & Gall model was simplified and focused on several main operational stages: (1) Needs analysis (preliminary study through observations and interviews at the school); (2) Design and preparation of the initial product draft (creating a prototype of modified equipment and the learning model guidebook); (3) Expert validation (expert judgment) conducted by specialists to assess theoretical feasibility; (4) First product revision based on expert feedback; (5) Limited scale field trial (small group); (6) Second product revision based on empirical findings from the small group; (7) Broad-scale field trial (large group); and (8) Final product revision to produce a learning model ready for socialization and implementation.

The subjects in this product trial research were students with mild intellectual disabilities attending SLB Bhakti Putra Palu, Mantikulore District, Palu City, Central Sulawesi Province. Subject selection was based on a purposive sampling method with the rational consideration that children with mild intellectual disabilities still possess sufficient cognitive potential, short-term memory, and receptiveness to respond to adapted motor learning instructions compared to moderate or severe categories. The field trial process was conducted in stages to ensure continuous improvement. The small-group trial involved 7 students to identify initial instructional and operational equipment weaknesses. Following revisions, a usage trial was conducted on a large group involving 13 students to measure the consistency and overall effectiveness of the product in a more realistic classroom setting.

The data collection instruments used in this study were structured with a mixed-methods approach to obtain rich data. The instruments consisted of: (1) Field observation guidelines; (2) Expert validation questionnaires using a Likert scale; and (3) Performance test evaluation sheets for field trials. The theoretical validation stage involved two academic experts and practitioners: one adaptive physical education learning expert and one table tennis sports expert. The validation instrument for experts was comprehensively designed to assess content feasibility, the suitability of biomechanical equipment modifications to the characteristics of intellectual disabilities, safety aspects, and the clarity of pedagogical instructions. During the field trial stage, the observation instrument was designed to measure 11 indicators of basic skill aspects, ranging from how to hold the paddle (grip), the ability to bounce the ball statically, service execution, ball return (block/return), to the students' level of attention during gameplay.

The data analysis technique employed in this study was a quantitative descriptive analysis converted into percentages, supported by descriptive qualitative analysis to process suggestions and improvement inputs. The numerical score data obtained from the expert validation questionnaires and field performance observations were statistically accumulated, and their feasibility percentage was calculated using the following mathematical formula:

$$P = (\sum X / \sum Xi) \times 100\%$$

Where P is the percentage of feasibility/success rate, $\sum X$ represents the total actual score obtained from all respondents for each assessment item, and $\sum Xi$ is the maximum ideal score achievable (number of respondents multiplied by the highest score). The results of the percentage calculation were then described and converted into standard product feasibility criteria: 80% - 100% categorized as "Highly Feasible / Usable Without Revision," 60% - 79% categorized as "Feasible / Usable with Minor Revisions," 50% - 59% categorized as "Less Feasible / Requires Major Revisions," and < 50% categorized as "Highly Infeasible / Total Replacement." Operational decisions to conduct revisions at each R&D stage were strictly based on written qualitative advice provided by validators and field notes from observing student motor performance.

RESULTS AND DISCUSSION

Needs Analysis and Initial Product Development

This research commenced with a needs analysis phase at SLB Bhakti Putra Palu. Initial observation results indicated a lack of interest and a high failure rate among students with intellectual disabilities when faced with standard table tennis equipment. Addressing these issues, an initial product development draft was designed in the form of an adaptive table tennis learning model. The most prominent modification in this product was a significant reduction in paddle weight. The standard paddle (150-200 grams) was replaced with a lightweight wooden paddle coated with sponge material, totaling 70-100 grams. This adjustment aimed to prevent students from quickly experiencing muscle fatigue in their arms and shoulders.

A second modification was made to the ball. Regular ping-pong balls were replaced with slightly larger plastic balls, colored in bright neon hues, and equipped with sound-producing elements (like rubber bells) that ring when the ball moves. This was intended to stimulate students' auditory and visual senses simultaneously, helping them track the ball's movement. A third modification involved game regulations, where strict table tennis rules were relaxed. Students were allowed to let the ball bounce up to twice on their side of the table before returning it. Finally, the product was packaged as a guidebook for teachers, containing repetitive pedagogical steps equipped with engaging visual illustrations.

Learning Expert Validation Results

The initial product prototype consisting of a guidebook detailing the models and court designs was subsequently submitted for validation by three experts possessing relevant academic authority and practical experience. The first validation was conducted by Sepak Takraw Coach Expert 1. Quantitative analysis of the validation questionnaire revealed a feasibility rating of 81% from Coach Expert 1, placing the model in the "Highly Feasible/Suitable for Use" category. Coach Expert 1 highly commended model variations 1, 5, 6, 7, 8, and 9, which achieved perfect scores (100%). However, he offered a critical evaluation and a very low score (25%) for the designs of model variations 2 and 3, indicating a need for instructional restructuring of those two drills.

The second validation was performed by Sepak Takraw Coach Expert 2, who awarded a slightly higher cumulative score of 86% (categorized as "Highly Feasible/Suitable for Use"). Overall, both coaching experts unanimously agreed that models integrating target and obstacle elements such as the "Relay Serve" and "Takraw Dice Challenge" were highly relevant for training accuracy (precision) and ball control (touch). Nevertheless, they offered minor suggestions for improvement, such as the importance of allowing students at least three repetitions for each model rather than a single attempt, which risks causing rapid frustration and changing the instructional terminology from "feeder" (pengumpan) to "ball tosser" (pelambung bola) to ensure greater precision regarding basic Sepak Takraw techniques.

Meanwhile, the third validation was conducted by an expert in instructional design (sports pedagogy). The assessment by this pedagogy expert yielded the highest rating 93% (categorized as "Highly Suitable/Ready for Use"). Focusing on instructional design, the expert awarded perfect scores (100%) for criteria regarding sentence construction, linguistic clarity, alignment with the characteristics of PJKR students, the engaging nature of the learning variations, and the clarity of instructional objectives. The expert emphasized that the guide's structure is highly systematic and that the proposed

design variations are theoretically capable of alleviating boredom and significantly stimulating student learning motivation during the course.

Table 1. Summary of Expert Validation and Field Trial Results

Testing/ Evaluation Phase	Achievement Percentage (P)	Eligibility Criteria
Validation by Sepak Takraw Coach Expert 1	81%	Highly Suitable / Ready for Use
Validation by Sepak Takraw Coach Expert 2	86%	Highly Suitable / Ready for Use
Learning Expert Validation	93%	Highly Suitable / Ready for Use
Field Trial – Small Group (n=7)	76%	Suitable / Usable
Field Trial – Large Group (n=20)	70%	Suitable / Usable

Results of Small-Group (Limited-Scale) Pilot Testing

Following the initial validation and revision phase, the model underwent empirical field testing with a small group representing the target populationspecifically, seven Physical Education, Health, and Recreation (PJKR) students. During the trial, students were instructed to physically perform the nine exercise variations in sequence and subsequently evaluate them via a questionnaire. The aggregated quantitative score for this limited-scale trial reached 76%, placing the product in the "Suitable/Usable" category.

Although the model was deemed suitable overall, a detailed item-by-item analysis (examining each exercise variation) revealed critical issues. Certain variationspecifically "Model Figure 3" (Relay Serve) and "Model Figure 5" (Point-Hunt Serve) received very low ratings, with scores ranging from 29% to 57% (falling into the "Unsuitable/Not Usable" category). Field notes and qualitative observations identified the root causes: students experienced disorientation and confusion due to the excessively rapid rotation patterns in the Relay Serve model, while finding the point-scoring system in the Point-Hunt Serve model overly complex and burdensome.

To promptly address these structural flaws, the researcher conducted a second (formative) round of product revisions. Corrective measures included simplifying the rotation mechanism for a more fluid flow, adjusting the scoring system to make it more intuitive, andmost importantlyoverhauling the guidebook's layout. The researchers added alphabetical identifiers (A, B, C) to the explanatory sections for each stage of the product's movements and bolded crucial keywords related to movement techniques to minimize ambiguity and clarify the gameplay procedures for both instructors and students.

Results of Large-Group (Large-Scale) Field Testing

The comprehensively refined learning model was subsequently implemented on a large scale, involving a group of 20 Physical Education (PJKR) students on the sports field. Evaluation results from this large-scale field trial showed a final achievement rate of 70%, validating the model's status as "Feasible / Suitable for Use."

Statistically, although there was a slight 6% drop in the aggregate percentage compared to the small-group trial, a natural and predictable outcome given the increased

heterogeneity in characteristics and motivation, as well as physical fatigue among the 20 respondents. Qualitative observations regarding the model's practical implementation in the field revealed a highly positive trend of improvement. Issues with rotational disorientation encountered during the small-group trial were successfully eliminated. Furthermore, modified models incorporating strong gamification elements such as the "Takraw Dice Challenge" and "Level Up Serve" garnered the highest levels of attention and enthusiasm. These two models successfully fostered an atmosphere of positive competition that compelled students to focus intently on target accuracy; because they were so engaged, they performed biomechanical repetitions without realizing it, thereby effectively mitigating the sense of tedium often associated with mechanical repetition.

DISCUSSION

Comprehensive research findings, derived from dual-expert validation and empirical field trials, substantiate a significant thesis: the development and innovation of sports technique learning models (specifically for table tennis or sepak takraw) intelligently integrated with gamification elements (play and competition-based approaches) are highly relevant, urgent, and effective for implementation within higher education curricula. Final feasibility metrics, consistently ranging from 70% to 93%, provide scientific justification that this underhand serve learning model serves as a tangible solution to key issues identified during the initial needs analysis phase: namely, alleviating monotony, eliminating boredom, and revitalizing the training process for basic underhand serve techniques.

Viewed through the lens of modern sports pedagogy, transforming the training structure from the old paradigm characterized by merely "standing still and hitting the ball repeatedly without a specific goal" to a new paradigm of "playing while training to overcome challenges" yields a profound psychological impact (affective domain) on students. Implementing model variations such as "Moving Target Serve" and "Fence Serve" mechanically compels students to refine their power control (precision in swing force), swing path accuracy, and intuition regarding parabolic angles and ball landing points in real-time. These findings strongly resonate with and reinforce the postulation by Lilo & Kungku (2024) that manipulating the training environment is essential for boosting performance. Furthermore, the introduction of external constraints whether in the form of static human barriers, targets like bottles or cones, or randomized instructions generated by a digital die roll in the "Takraw Dice Challenge" model serves a vital function as a cognitive distractor. This challenge shifts students' cognitive focus away from excessive anxiety and the fear of making mechanical errors in front of peers, redirecting it instead toward spatial problem-solving strategies and achieving the game's objectives. Such environmental modifications create a learning atmosphere free from psychological threats in a non-threatening environment. According to contemporary learning theory, a safe learning environment structured around proportional challenges provides the ideal setting to solidify a learner's intrinsic motivation (Asyafah, 2019).

One of the most successful policy revisions in this study was the introduction of a rule granting students the privilege of up to three attempts or repetitions before incurring a rotation penalty. This simple regulation has proven scientifically crucial to the neurological mechanisms underlying muscle memory development. When executing closed-motor skills such as the underhand serve in sepak takraw, where the environment remains static prior to the ball being tossed, students absolutely require

repetition. Repetition allowed within a framework that tolerates failure significantly boosts the learner's self-efficacy. Students are afforded sufficient freedom regarding time and space to perform motor calibrations such as adjusting the angle of contact between the ball and the inner foot or modifying their stance distance based on the sensory evaluation (feedback loop) derived from their initial failed attempts. From a holistic and integrative perspective, this learning model is not merely effective in accelerating physical literacy, leg strength, and the fundamental biomechanical skills of sepak takraw. Moreover, it plays a highly positive psychological role by alleviating the students' endemic boredom on the sports field, fostering a spirit of cooperation, and stimulating healthy competition. Nevertheless, the researchers acknowledge certain methodological limitations. The primary limitation of this development study is that the product's precise level of effectiveness has not yet been measured through pure or quasi-experimental methods (such as a statistical comparison of quantitative pre-test and post-test data regarding target-specific service accuracy). Therefore, future research is strongly recommended to empirically demonstrate using inferential statistics the significant impact of this game-based model on enhancing students' kinesthetic performance.

CONCLUSION

This research and development (R&D) initiative systematically and comprehensively designed, validated, and executed an innovative product: a learning model for the sepak takraw underhand serve technique. The model proved to be valid, highly practical, and interactive for implementation among the Class of 2023 students of the Physical Education, Health, and Recreation (PJKR) program at Tadulako University. The model's validity and pedagogical feasibility were confirmed and legitimized through a rigorous expert assessment process. A pedagogy expert assigned a validity rating of 93% ("Highly Feasible"), while evaluations from two professional sepak takraw coaches yielded a high average feasibility score of 83.5% ("Highly Feasible"). Empirical success in the field was also evident; the model maintained an operational practicality level of 76% during small-group pilot testing and achieved a stability score of 70% ("Feasible/Ready for Use") when subjected to the heterogeneous dynamics of a large-group trial involving 20 students. The pedagogical innovation features nine tactical drill variations infused with game-based elements such as the "Takraw Dice Challenge" maneuver, "Moving Target Serve" agility drills, and "Obstacle Serve" accuracy tasks all structured within a guidebook featuring clear instructions and visual layouts. This holistic approach proved effective in combating widespread boredom and reigniting intrinsic motivation; it successfully facilitated student mastery of the biomechanics of motor skills and underhand serve accuracy through a highly competitive, challenging, and enjoyable ("joyful learning") experience. Based on these robust conclusions, this guidebook and learning model framework are highly recommended from both academic and practical standpoints for adoption, utilization, and dissemination by lecturers, instructors, and sports coaches. They serve as a primary reference and a practical methodological alternative for guiding sepak takraw practical courses in higher education. To optimize the model's function and future impact, instructors are advised to continuously re-evaluate, adapt, and calibrate the complexity of these training models, aligning them with the available physical facilities and the varying levels of students' motor proficiency at their respective institutions. Finally, to pave the way for further research and scholarly development, it is strongly recommended that future

researchers expand upon this model by adapting it for modern digital platforms, such as mobile applications or interactive 3D audiovisual modules (e.g., video or VCD). Furthermore, conducting follow-up research using a true experimental design specifically a pre-test/post-test control group approach is essential to scientifically and measurably assess and statistically validate the model's effectiveness regarding improvements in students' service accuracy.

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